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Time Response Ambulatory Calls Evaluation

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An Interactive Qualifying
Project

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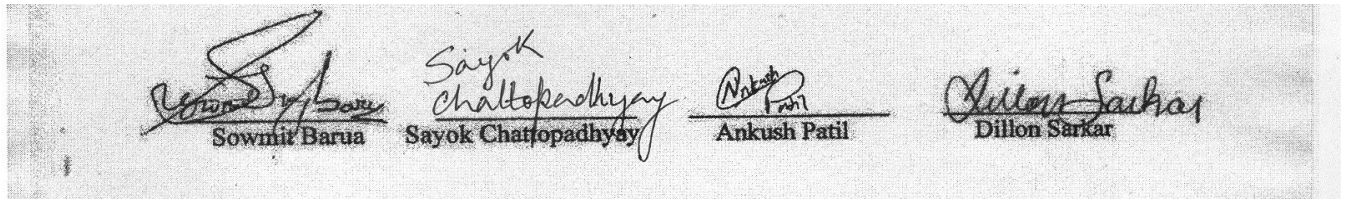
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In partial fulfillment of requirement for the

Degree of Bachelor of Science

By

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ABSTRACT

Time response is an important aspect of pre-hospital emergency care. With the rapid growth in population all around the world, medical assistance has to be at its best to be able to best serve the society. Time response is measured from the time the patient dials 9-1-1 to the time an ambulance, or any other type of medical assistance, reaches the site. This is a critical statistic as it can help in saving many lives, just by giving the care at the earliest time possible. We have collaborated with the University of Massachusetts Memorial Medical Center (UMASS) Garage. Working with the paramedics at the garage and from interviewing them, we found some crucial data that assisted us in the research. A thorough analysis was conducted on the EMS systems and time response data in the United States and the United Kingdom. After the analysis, possible technological and engineering solutions were considered, analyzed, and recommended. Some of the solutions analyzed, both infrastructural and technological, included the Opticom system, the 3-1-1 call system, Q-CPR, Advanced Automatic Collision Notification, NG-911, Micro-bus Personal Computer, and the Tabu Search. All these solutions were thoroughly researched and a method to its implementation and improvements in the United States, especially in Massachusetts.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF GRAPHS

ACKNOWLEDGEMENTS

CHAPTER 1. EMS TIME RESPONSE AND ITS IMPORTANCE

With a cumulative positive growth rate, population is expected to rise around the world during the next decade. Due to this increase, emergency response systems have become more important than ever. Talking to one of the paramedics at the UMass Memorial, we learned that the call volumes are escalating and will continue to escalate as time passes. Not only will the quantity of calls increase, but also the quality of the responses will have to ameliorate as newer technology can be implemented. This project will aim at improving the time response for emergency medical services, ambulances in specific. Time response is a major component when measuring the quality of a medical service. The quicker an ambulance reaches its patient the more time the medics have to work on the patient. It is very important to understand that time response for ambulances is measured form the time a patient dials 911 to the time the ambulance reaches its patient and is able to provide medical assistance. Over the years there have been definite improvements in time responses. With the United States making it a requirement to own a health insurance for each person, people are now not afraid to call an ambulance for even minor injuries that do not require immediate assistance. A paramedic at UMass Memorial told us that they receive about 80 calls per day, out of which only 75% are transported to a medical facility.

The primary objective of this project is to evaluate the time responses in the United States and various other countries, and come up with solutions to ameliorate the time responses for ambulances. Solutions implemented in other countries outside the United States will be researched. These technological solutions are investigated in detail and the problems with the use of these technologies are evaluated. Possible solutions to these problems are thought of and discussed. Creative solutions will be provided and a suitable test environment will be chosen to execute and implement the solution.

This report consists of three more chapters after this one. Chapter 2 talks about the various time response data in the United States split into 3 parts: East, Central, and West. It also discusses the time response data from the United Kingdom. Using the data, graphs were formulated and a thorough analysis on the data was performed. In Chapter 3, technological solutions to ameliorate time response were produced. Some of the solutions originated outside the United States, but a proper method to implement it in Massachusetts and other states was thought of. Chapter 3 also discusses the possibility of combining two or more technologies together to enhance the user interface of the product and make it possible for EMSs to arrive on site faster. Chapter 4 concludes the report giving a brief summary, limitations, and future improvements.

CHAPTER 2. TIME RESPONSE DATA EVALUATION AND ANALYSIS

2. Introduction

Today emergencies are more complex than we have seen in previous years. With the increasing number of population, rapid climate change as well as economic downturn; one of the major complexities for this project is to analyze and improve on those complexities as well as the ones that have already existed since the beginning of EMS system. As we try to work toward a solution in improving the emergency response system that exists today; our first step is to analyze the complexities that have existed since the establishment of EMS and evolved with the technological improvement. Then we will analyze and relate those complexities with the EMS data that we have gathered from various parts of the US as well as various parts of the world. As proposed by the research by Sakarya University, there are six different types of complexities which can affect Emergency Medical System. Those complexities are:

1) Human Complexity,

2) Technological complexity,

3) Event complexity,

4) Interaction Complexity,

5) Cultural Complexity, and

6) Decision making complexity.

Along with those complexities we also analyze the impact of Economic complexity. Although we talked about including climate change as part of the complexities, since it can be

considered as part of event complexity we will exclude that from our analysis. As our research model we will be using the data from Texas EMS and Detroit EMS. For the clarification purpose we will briefly describe each of these complexities before analyzing the data.

Human Complexity: Two of the major components of emergency medical system are humans and technology. In emergency situations human error can turn out to be fatal. Even a really well designed advanced EMS system can be proven ineffective if the operators in charge of it can't operate at the optimized level. Other factors that can contribute to this complexity are- fatigue, workload, fear as well as cognition overload, forgetfulness, inattention, poor motivation, carelessness, negligence, and recklessness (Reason, 2000). Therefore, human related complexities must be dealt with in order to optimize the EMS system in general.

Technological Complexity: Another vital component of EMS system is technology. With the rapid improvement in technological field almost all the EMS system in the world now use some sort of technology. Although these systems are being controlled by computer software, the number of sub-division in the overall system can increase the complexity of the system. Timely communication among responders relies on the establishment of robust and efficient communication infrastructures (Chen et al, 2009)

Event Complexity: This refers to situations where there is a big amount of destruction caused by a catastrophe that can slow down response time by an emergency response team. Usually hurricanes, tsunamis, floods or catastrophic situations like these fall under this category. These situations often create huge property damages and human deaths prevent EMS workers to work at their optimized level. Climate complexity is considered as part of event complexity

due to increased natural disasters. Recent studies show there is a higher risk of natural

disasters due to the increased number of greenhouse gas in our atmosphere. Hence in order to

work towards to an optimized EMS system we have to consider these situations which were

not considered while designing EMS systems in the past.
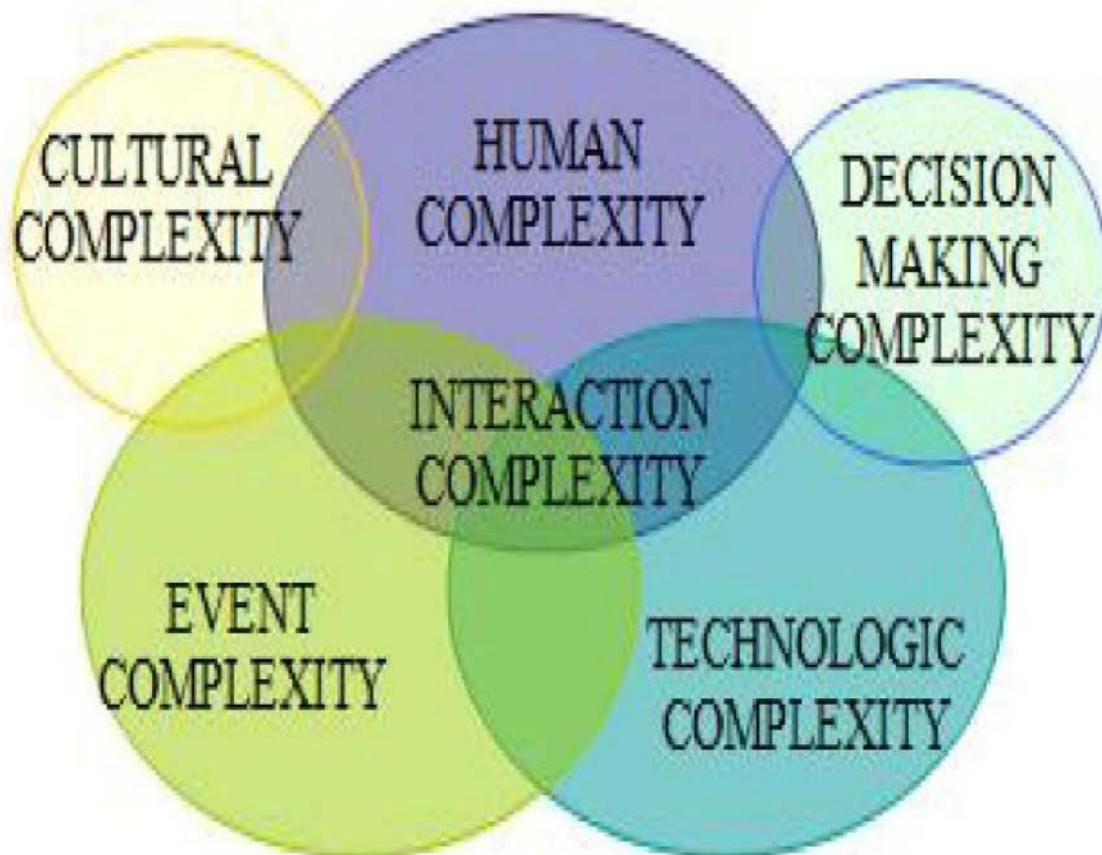
Figure 1: Representations of Factors of Complexities in EMS

Interaction Complexity: This refers to organizational and administrative complexity. In case

of an emergency a big amount of human error can be eliminated with proper organization skill

and interaction among EMS personnel. On the other hand, a poor interaction among EMS

personnel can make the situation even worse. The need for integration intensifies as the

number of organizations engaged in response operations increases and the range of problems

they confront widens (Comfort and Kapucu, 2006). Hence, a good integration of

organizational development training program for EMS personnel should be included in designing an optimized EMS system.

Cultural Complexity: Every day the world is becoming more and more diverse. Due to the development in technology people tend to travel more; hence countries are more multicultural now than they ever were. Thus, what worked for EMS personnel 30 years ago is almost obsolete now. While EMS personnel only had to deal with a certain society in the past, now they have to deal with people who can come from culture where a male EMS staff helping a female in casualty can be considered sensitive. Hence, EMS must consider all the factors that will satisfy all sorts of cultural issues.

Decision Making: It is always difficult to make the right decision in times of emergencies. During emergency response, individuals, teams, and organizations share and apply knowledge as they process information, make decisions, and act on existing knowledge (Chen et al, 2009). There are two major sub-complexities for decision making- (i) User interface complexity and (ii) Explanation Complexity. According to Erman and Dilek, "In order to make good decisions, user should be well informed about the situation, alternative decisions should be determined and evaluated, and the results of each alternative must be presented" (Complexity in EMDRIS). Hence, while designing an affective EMS system, we have to make sure the operator and the personnel involved have the most information available at any time while dealing with an emergency.

2.1 Eastern United States EMS Analysis

The Eastern United States consists of 3 major regions The South, New England, and The

Midwest. As of 2011, the estimated population of the 26 states east of the Mississippi River (used

as a reference for locating the Eastern States) totals to 179,948,346 out of the 308,745,358 in the

whole nation, or 58.28% of the US Population. From the east of the United States, we will now be

looking primarily at the states bordering the Atlantic Ocean, or known as the East Coast of the

United States. The East Coast of the United States, comprises of 17 states; Maine, Vermont, New

Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware,

Maryland, West Virginia, Virginia, North Carolina, South Carolina, Georgia, Florida, and

Pennsylvania. These 17 states that stretch out from Maine to Florida, consist of 112,642,503

people as of the 2010 Census, about 36% of the entire US population.[8] Figure 2 displays the

Figure 2: East Coast of the United States

Eastern Coast states in red. From the figure, one can easily tell how small a portion of the United

States these 17 states really are. The 17 states combined have a land area of about 1,160,659

square meters, which is about 12% of the total US area.[8]   When you have 36% of a country's

population living in 12% of the country's land, there are bound to be minor problems due to

population density. The demand of any service will exceed the supply of that service. This is where the Emergency Medical Service (EMS) comes under evaluation. The east coast also consists of some major cities such as New York City, Boston, Philadelphia, Washington D.C., Miami, and many more. These cities are so active and densely populated that a good EMS system has to be in place. Now we will analyze the EMS systems in some of these states, to see how they function and analyze the time response data they produce.

2.1.1 The EMS System in Rochester, NY

The City of Rochester is a sub-urban community with a population of 201,000 in 2010. The city government is composed of an elected mayor with a city council. Rochester provides extensive government services typical for many urban communities. Like most other municipalities, it has been challenged by the recent economic situation that included a proposed $7.4 million cut in funding provided by the state. The resident population of Rochester has decreased from 218,000 in 2001 to 207,000 in 2007, about 5.5 percent in 7 years.[9] If this trend

Graph 1: Rochester, NY Population Trend
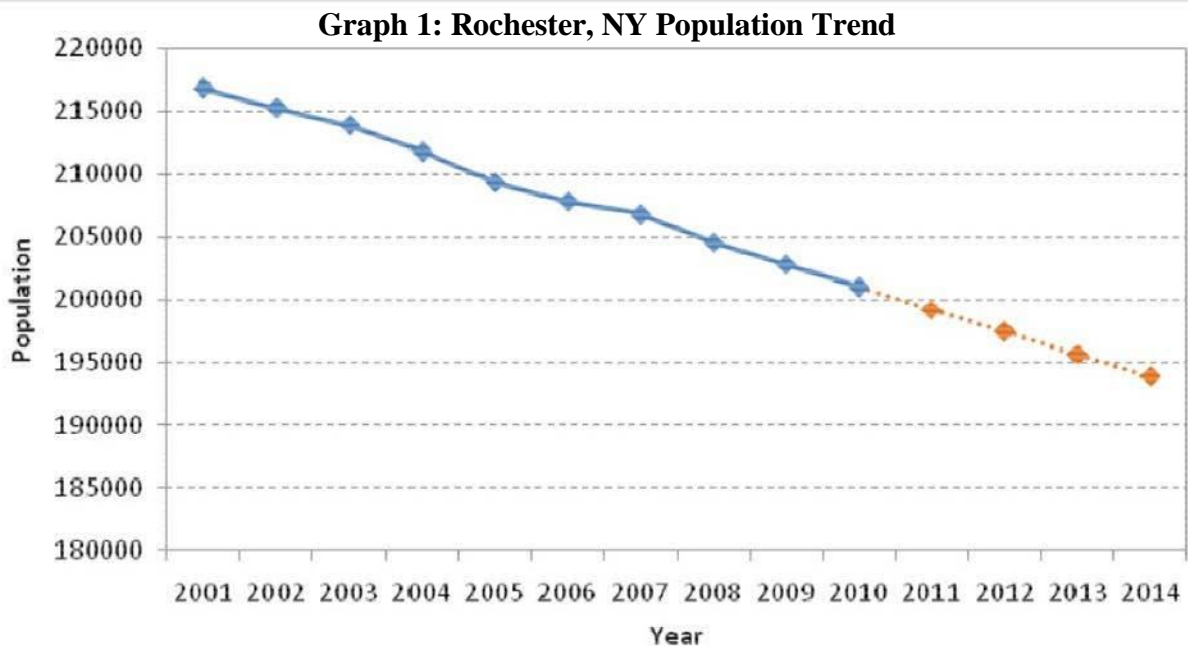
continues, as is expected, the population forecast would be as shown in Graph 1, going below

195,000 by 2014. We know the economic condition of Rochester is getting worse as less

money is provided for funds. This means that the city council of Rochester will have to cut

some of the funds it distributes to the medical service department. That means that fewer

EMTs and Paramedics will be appointed per dispatching center. Fewer funds will be available

for maintenance and upgrading of vehicles and medical supplies. Now considering these

changes due to budget cuts, a reason for the decrease in population can be interpolated. People

are starting to move out from Rochester, a sub-urban city, to a more urban city, for example

New York City, for which we will analyze the EMS system and time response data later.

To evaluate any EMS system and time response data, the starting point will always be to

analyze the 911-call process. Included within the EMS dispatch system is the primary safety

answering point (PSAP), the primary dispatch access point (PDAP), medical priority dispatch

(MPD), and computer-aided dispatch (CAD). In the city of Rochester, the EMS dispatch system

is under the control of the Emergency Communications Department (ECD). The ECD is

managed and staffed by the City, and therefore any budget adjustments will directly impact the

EMS dispatch system. The dispatch centers handle over 1.2 million calls and dispatches annually

with most being police related. The ECD employs 192 communications professionals, with 179

being assigned to operations. All operations personnel are trained as Association of Public-Safety

Communications Officials (APCO) telecommunicators and are certified as emergency medical

dispatchers by the National Academy of Emergency Dispatch. Operations personnel receive a

minimum of four months of telecommunications training and six months of dispatch training

prior to being allowed to perform without intense or one-on-one supervision. There are 30–35

Graph 2: EMS Call Volumes in Rochester, NY
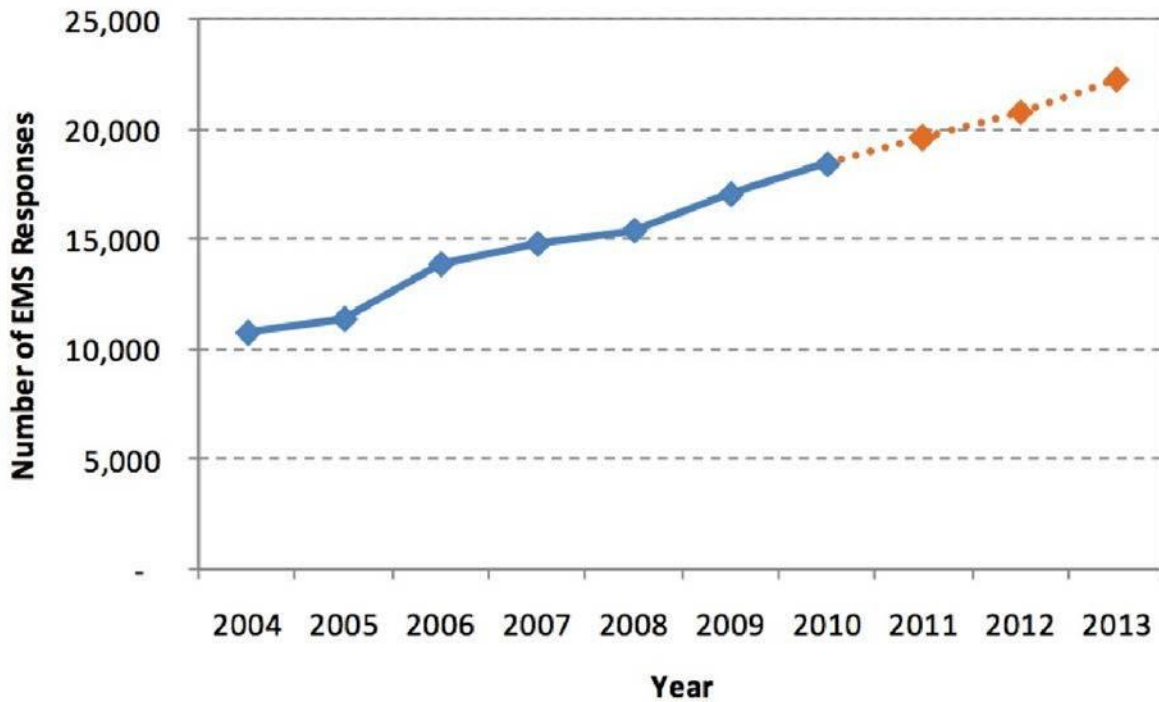
call-takers and dispatchers on duty, handling 911 access, fire, police, and EMS incidents. [3] In

Rochester, the primary safety answering point (PSAP) for EMS, fire, and police is the ECD. In

2008, the City enacted a CAD update to keep better account of dispatch activities and

dispatchers/call takers. Phase II of the radio system upgrade was recently completed and the

phase II of the cellular system upgrade was completed four years ago. The ECD can identify

locations of cell phone calls that account for over 55 percent of 911 call reports. This ameliorates

the time response, as the location of the patient is known to pin point. Also the time required to

state an address is disregarded. For EMS incidents, the 911 call takers are responsible for

initiating the Medical Priority Dispatch System (MPDS) by assigning roper codes to each call

and providing pre-arrival EMS instructions to the caller. The ECD uses the MPDS in order to

prioritize EMS requests and provide pre-arrival instructions to callers. Prioritizing EMS requests

plays a major role in recording successful dispatches, which is when the patient is successfully

transported to a medical facility.

Now since the initial process has been evaluated, the secondary step in the system is looking at the actual time response for the ambulance. This time is measured from when the dispatcher reports the case to an EMT or Paramedic, who then takes off from the garage to the time medical assistance reaches a patient. The world population, as we know it, is increasing daily, which means the number of 911 calls will also be increasing. As seen in Graph 2, call volumes were close to 10,000 in 2004 and in 2010 it went up till 18,000. From the trend line, it is predicted to go up 23,000 by 2013. That is about 5,000 more call annually within the next 2 years. It is interesting to note that even though the population has decreased, EMS response increased. We hypothesize that this phenomenon occurs in sub-urban centers for a variety of reasons.

1. Residents who continue to live in sub-urban centers tend to be senior citizens or part of the lower economic strata. These groups tend to use EMS more than others.

2. Sub-urban centers experience reduced access to primary care, causing these citizens to delay access to care until their illness or injury develops into an emergency condition. This is often seen in communities where a higher percentage of residents are uninsured or under-insured.

3. The EMS system has developed a greater rapport and trust within the community, leading to increased willingness to activate EMS.

4. Community education programs emphasize the need for early notification of 911 to decrease the mortality and morbidity experienced from acute coronary syndromes and stroke.

We see why the call volume is still increasing, even though the population of Rochester is decreasing. The EMS dispatch centers have to be able to reallocate resources accordingly, when call volumes exceed the supply of the service. In order to do so, first an in depth analysis has to

Graph 3: EMS Call Distribution in a Week
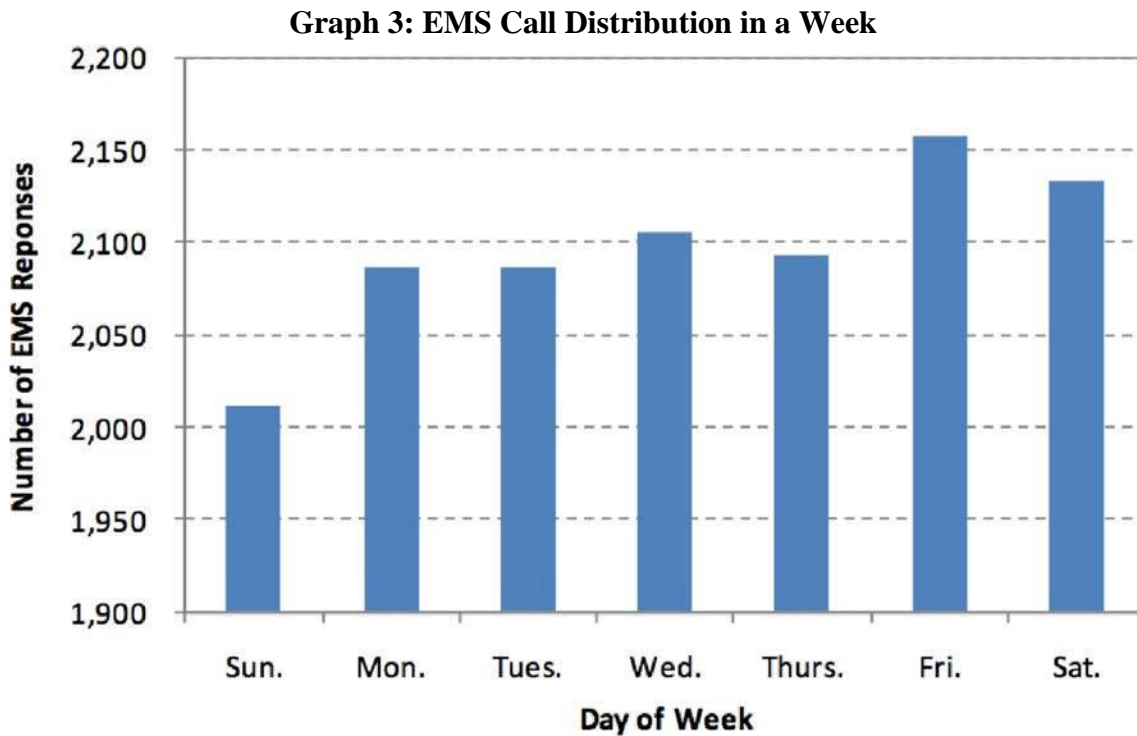
be made on when the calls are placed. This way the dispatchers can set up resources accordingly. For example, Graph 3 shows how the calls are distributed day by day, on an average week. As seen from Graph 3, call volumes tend to increase towards the start of the weekend, Friday and Saturday. On Sundays, the calls seem to be evidently fewer. If a dispatch system were to look at this graph, one thing they could do to improve their system would be to be staffed with a greater number of paramedics/EMTs and maybe a few ambulances extra. This would allow them to adjust the increase in call volume. Just like the day of the week, the time of the day could also be important in determining how to staff an EMS dispatch center. Rochester, being a sub-urban city, is busiest between 10:00 AM and 10:00 PM, with a considerable reduction in calls after 10:00

PM until 7:00 AM. Graph 4 indicates this trend. At around 10:00 AM, people are hustling to

work, students are attending classes, and the stores open up for business. The highest peak on

that graph occurs at 6:00 PM. This is when all the people are returning home in a rush from a

busy day, stores are closing for business, and students are heading back home after classes.

Looking at this graph, it is quite easily understood when the peak times are, and therefore the

dispatch centers supposed to have more people working in the day shift and fewer working in the

night shift. Graph 4 also shows when the greatest number of priority 3 and priority 2 calls are

made. This also occurs between the time periods of 10:00 AM to 10:00 PM. An induction can be

Graph 4: EMS Call Distribution on an Average Day
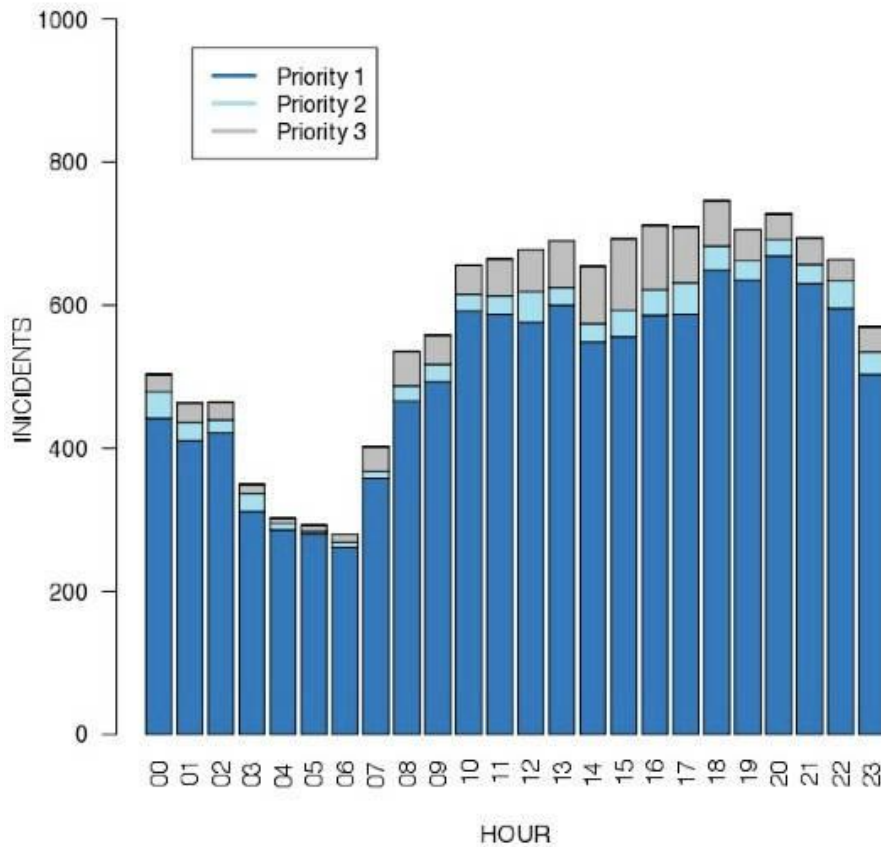
made from this. People tend not to drive themselves to the hospital when a minor injury, or a

priority 1 incident, takes place. They feel much safer calling 911 to take them to the hospital for

medical care. Due to this, the unnecessary calls will be made, just as insurance for the patient.

All these factors come into play when the dispatch centers are operating day and night for 365

days a year.

2.2 Southern United States EMS System Analysis: Texas

Over the period of last few decades, EMS system in Texas has gone through a dramatic

change. EMS in Texas has turned from funeral homes with under-trained crew members to state

of the art hospital with highly trained personnel. As late as the early 1960's, EMS was not

viewed as a component of the healthcare system, but rather as a transport method comparable to

the crude manner injured soldiers were removed from the battlefield during the Civil War 100

years earlier (Texas EMS). With the increasing population in Texas; especially being one of the

Graph 5: Projected Population growth of Texas

Source: Texas State Data Center.
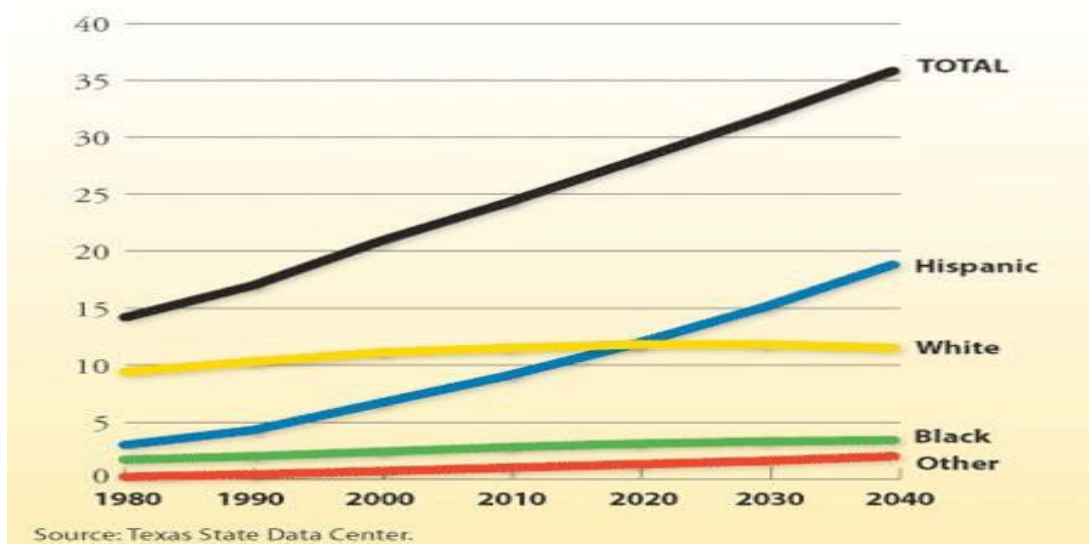
most popular states for migration, a perfect state for multi-company establishment, and neighboring Mexico led to the rapid increase in the population of Texas. While the population of the second largest US state used to be around 14 million in 1980; in 20 years that population almost doubled to be 24million. If this trend continues, the population is projected to be around 36 million, which is shown in Graph 5. To keep up with this rapid population and to provide the state of the art healthcare to the people of Texas; EMS was integrated as part of Texas Trauma System which was established in 1989.

2.2.1 Challenges for Texas EMS

With the ever increasing population there is also an increased demand for EMTs and EMS personnel in order to keep up with the amount of emergency calls and prompt response to emergencies. Despite being one of the most stable economic states in the US; it is almost impossible for the state official to keep up with the increased expenses for the EMS personnel. This means either a personnel cut which can lead to poor response time in times of emergency or a cut in updating the equipment which can lead to poor performance during emergencies. Additionally, Texas has approximately 3.2 million people residing within 210,663 square miles in rural and frontier counties (Texas EMS report). Usually EMS staff is smaller in rural areas and a budget cut means even smaller EMS personnel. Also as rural EMSs are the last ones to be updated to modern equipment, a budget cut can lead to fatal incidents as well as less productivity from the EMS. Besides vast distances between communities, paired with the distances from hospitals with advanced equipment, hindrance in delivering proper care to the injured ones are some of the challenges that EMS personnel have to overcome in order to provide appropriate
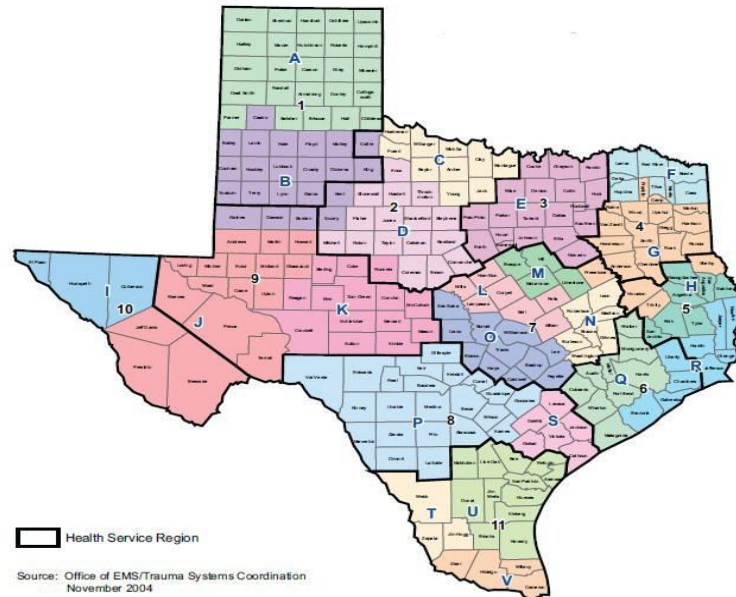
Figure 3: Texas Trauma Service Areas and Health Service Regions

help. Language barrier is another challenge that the EMTs have to overcome as a big portion of

Texas population is minority, especially in the border communities. The Texas Workforce

Commission has reported that bilingual and Spanish-speaking residents comprise more than 20

percent of the population of rural Texas (Texas EMS).

According to a research by Texas EMS there are a lot more specialized physicians

practicing in the urban areas than in the rural areas. Also the number of hospitals and primary care

physicians are grater in the urban areas than rural areas. Hence when a call is received in the EMS

system from a rural area the response time is usually higher which can increase the fatality in case

a huge disaster.

2.2.2 Analysis of EMS Data

As stated above, EMS personnel in the Texas rural areas are significantly lower than in the

urban areas. Only 20 percent of the approximately 15000 paramedics provide service in the

rural areas (Texas EMS). This is quite insufficient for the increased number of population who tend to visit Texas for vacation and leisure purposes. According to data collected by the Texas Department of Health Bureau of Epidemiology (now a division of Texas DSHS, Texas EMS/Trauma Registry) few rural areas throughout Texas have patient response times up to 136 minutes and hospital transport times of up to 132 minutes (Texas EMS). On top of that 157 of 254 counties have response times higher than 10 minutes. And 151 counties have patient transport times higher than 20 minutes. From the chart below we can see how the response time in the state of Texas varies. While the communities surrounding the metropolitan areas have a higher response time (5-8 minutes); the response for outlying areas can vary from 15-40 minutes. In case of a serious injury like cardiac arrest or unconsciousness; this 15 minutes can turn out to be fatal. From a research done by Pilot Project some of the problems that contribute to this poor response time in Texas EMS can be seen in Graph 6.

- Data is not maintained by the state to be able to properly identify the number of EMS

  certified individuals in Texas.

- There is no standard certification or licensing required for people in charge of PSAPs

  (Public Service Answering Points)

- There is no standard policy or procedure for systematic documentation of the

  nature or outcome of 9-1-1 calls resulting in dispatch of an emergency medical

  response unit.

- Small operational-level PSAPs often only staff with one dispatcher per shift,

  thereby limiting their ability to stay on-phone with callers requiring extended

  assistance.

- Not enough revenue for the proper training. Additionally the wage for

  the EMTs appointed in the rural areas is lower than the ones in urban

  areas.

In order to improve the EMS response time we have to take all these factors into

consideration as changing few or all of these can make a huge improvement in EMS

response time and prevent serious fatalities.

2.3 Detroit EMS System: Performance Issues

Another major state we will discuss in this project is Michigan. Although we would like

to the analysis on the state of Michigan; due to in-significant data we will focus on

Detroit. Over the last few years the EMS system in Detroit has been criticized multiple

EMS Response Times by Trauma Service Area, 2002
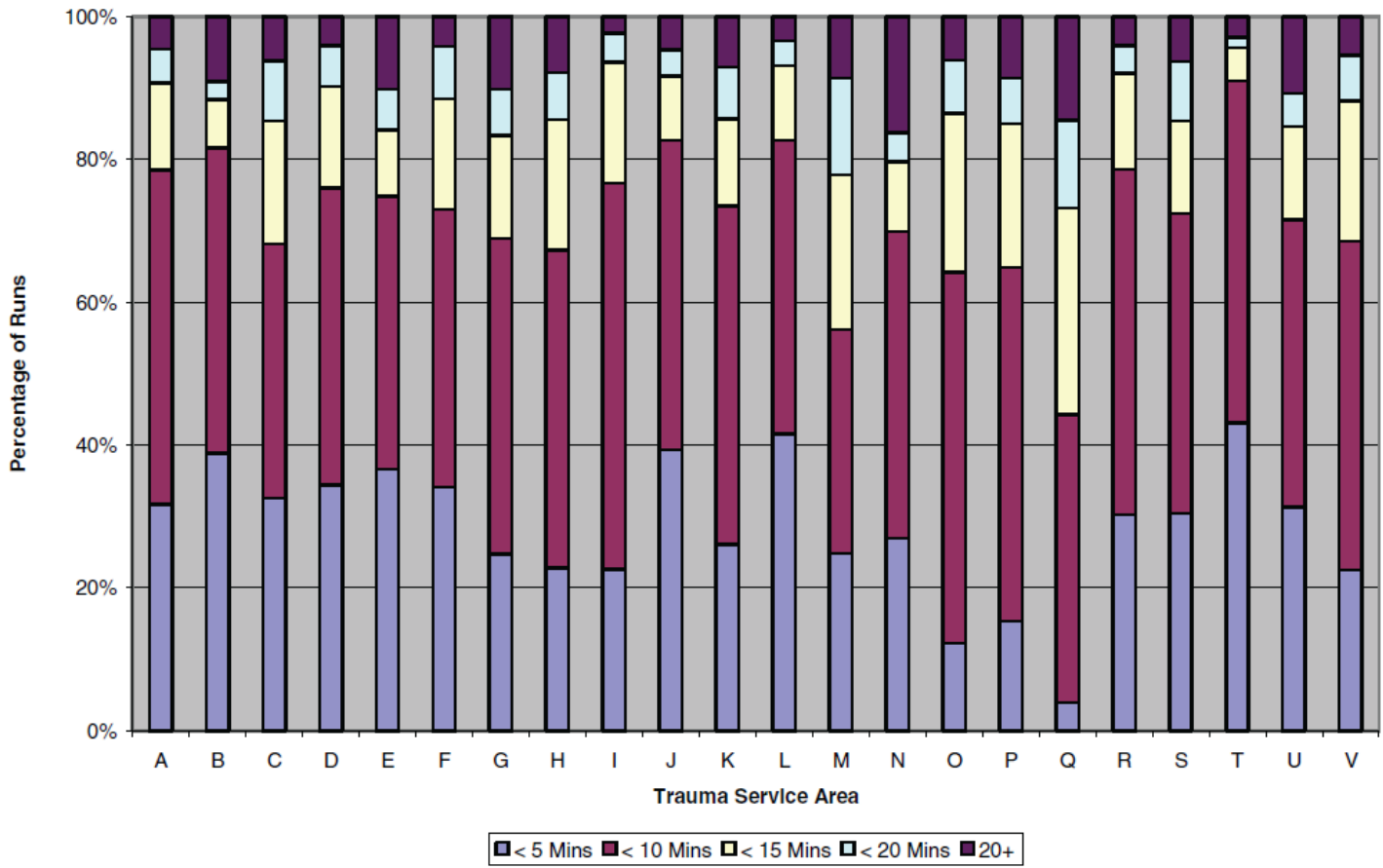
Graph 6: EMS Response Times in Texas

times for having one of the worst response times in the US. While the national standard time is 8 minutes; Detroit EMS has a response time of 12 minutes. (Fox Detroit) Although this is one of the poorest response times in the country, there are few reasons that contribute towards this. Although with time major cities in Texas and the state of Texas are economically improving; it is complete scenario in Detroit. For the last few years the city of Detroit has been in economic decline. The unemployment rate for the city of Detroit is about 11%, which is higher than the national average. These unemployed people often seek state and city sponsored benefit programs which limits both the state and city wide budget cut. As majority of the EMS are controlled either by city or the state this leads to a budget cut for the EMS department. With fewer EMS personnel it is almost impossible for EMTs to respond to one of the densest cities in the US. With 139 Square miles of area and only 25 medic units Detroit is one of the toughest areas to cover in the country.

Every year over 160000 calls are received which is more than over-whelming for the 25 EMS units that serve the city of Detroit. Additionally, Detroit lacks the three party EMS systems that other major cities have implanted in their systems. While in most major cities Fire
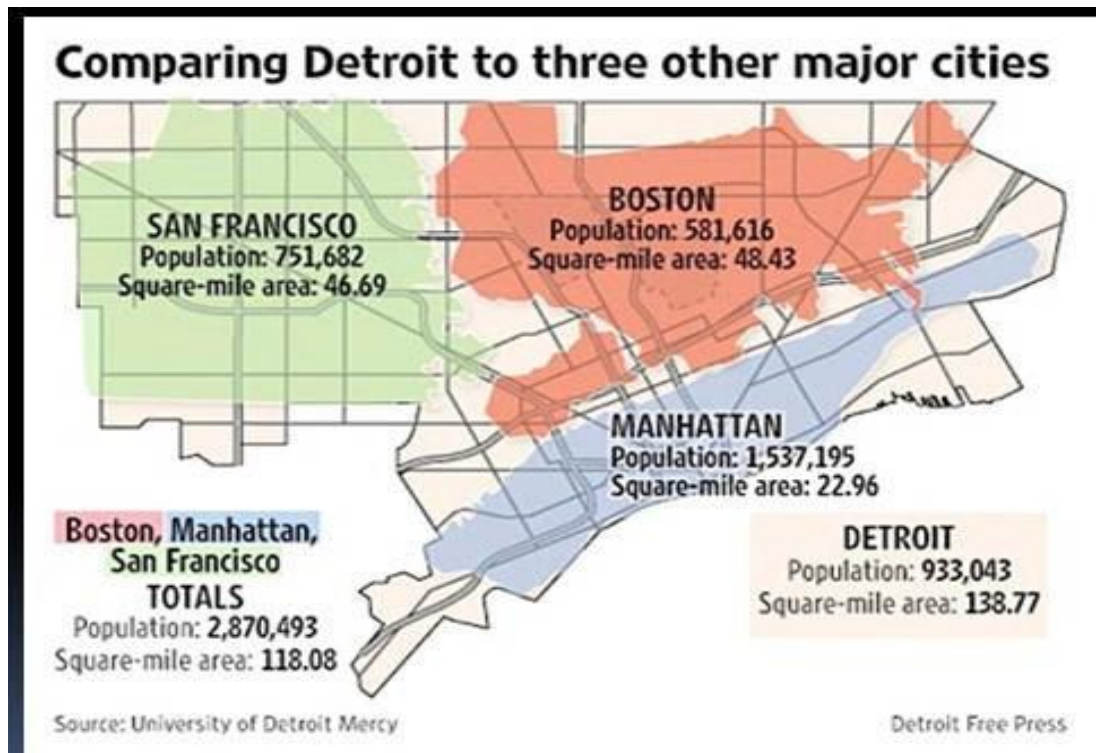
Figure 4: Population Density in Detroit compared to three other major US cities

Department plays multi-role and EMS service in provided by a Third party transport agency, in Detroit Fire Department plays the role of PASPs, Dispatching, responding and transporting patients to the hospitals. In order to improve the response time the city of Detroit needs to implement the Multi-role system that exist in major cities. One of the unique systems that exist in Detroit is 3-1-1 system. Hence the city need to educate people when to call 911 and how to utilize 311 as doing so can reduce the number of life-threating EMS call dramatically and improve the EMS response time.

2.4 Western United States EMS Analysis

The Pacific Coast, which is most commonly known as the West Coast, includes many states on the most western side of America. The ideal West Coast is thought to be as

the three states of Washington, Oregon, and California. The noncontiguous states such as Alaska and Hawaii do boarder the Pacific Coast, but do not fall under the category of West Coast. According to the U.S. Census group the three states of California, Oregon, and Washington form together as the Pacific region. The states of Nevada and Arizona are also considered as the west Coast because they are greatly influenced by the West Coast states, especially from California. These regions are fairly new due to the fact that the history of these regions was discovered after the East Coast.

Although there is no official Federal or State standard for response times for ambulances in US, standards do exist amongst communities and EMS provider organizations. However, these regulations are not based on a single standard and that is why standards vary quite frequently not only within states, but also amongst states. It is a general consensus that time-response for ambulances in emergency calls should be within 8 minutes 90% of the time, although, that is easier said than done. These responses vary significantly during times of crises as cities find it difficult to meet all demands and regulations at the same time. The most pronounced problem, however, is that the data is highly unreliable. EMS service providers don't always record the times with accuracy. Moreover, the data that is publicly presented is even more skewed as sometimes only the data which shows efficient and favorable response-times is revealed. In an article in 'USA Today' (2005) Robert Davis says, "The best test of an emergency medical system is how many 'saveable' victims of sudden cardiac arrest it actually saves. These patients must be reached and shocked with a defibrillator within six minutes, or they almost always die"(USA Today).
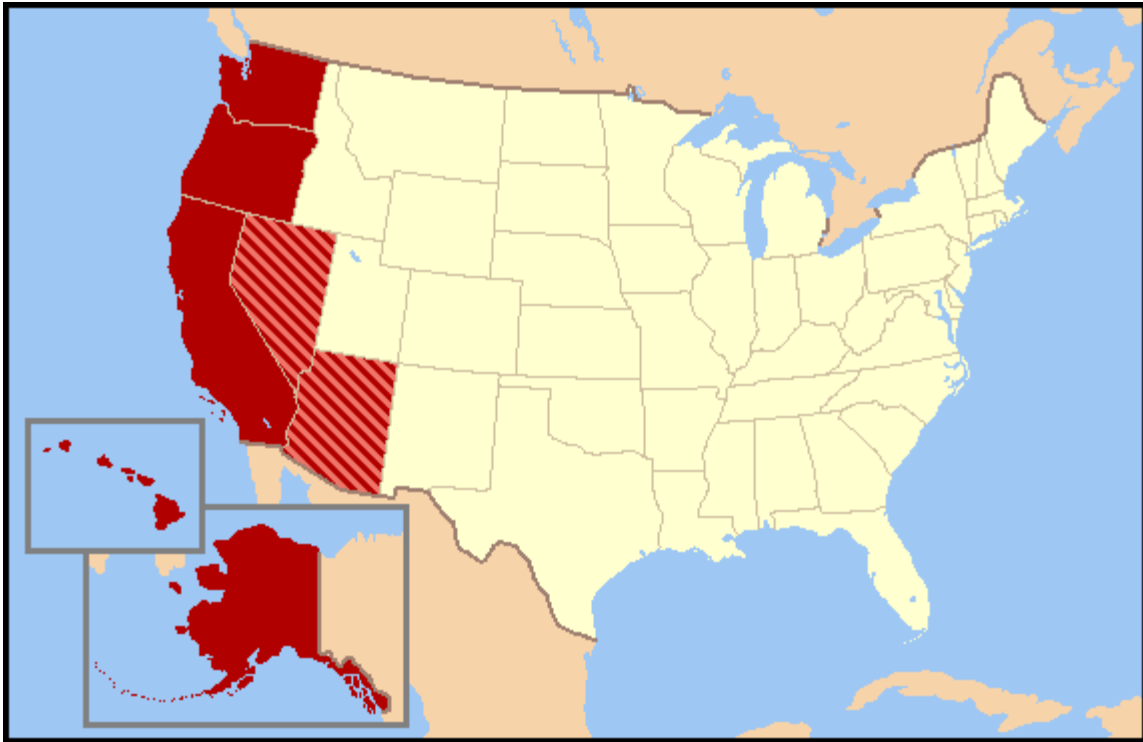
Figure 5: West Coast of the US

In the article "The Price of Just a few Seconds Lost: People Die" (2005) Robert Davis points out that the majority of the nation's largest cities save emergency 6-10 percent of emergency cardiac arrest cases, when around 20% or more could be saved. USA Today's analysis shows that "Few cities know exactly how long their emergency crews take to reach cardiac arrest victims, and most are selective about how they portray their performance. Only nine of the 50 largest cities track their response times precisely enough to know how often emergency crews reach the victims of cardiac arrest within six minutes" and "Most other U.S. cities don't know their response times, refuse to disclose them or use imprecise measures that are meaningless in determining whether emergency crews reach victims in time to save them. This situation persists even though research clearly has shown that precise measuring improves performance and saves lives. Houston, for example, went from a near-zero survival rate for sudden cardiac arrest to 21% after it started to measure and fix problems that became clear (USA Today)."

Larger cities in the west coast have bigger problems and these are less susceptible to change. With that in mind, the survey provides evidence that these cities have the best utilization of the call-to-shock measurement and the highest survival rates. Seattle has been outstandingly above average amongst the nation's 50 biggest cities. Seattle has a 45% survival rate and on average they were able to reach the scene within 8 minutes and 46 seconds to perform the procedures for victims in cardiac arrest. In this time, the CPR takes about 90 seconds alone.

However, survey shows that some of these cities have made the best utilization of the call-to-shock measurement and have the highest survival rates. "Seattle had a 45% survival rate, highest among the nation's 50 biggest cities. On average, Seattle's emergency crews took 8 minutes 46 seconds to shock victims of sudden cardiac arrest. Here's a table on some research data on other cities conducted by USA Today for the year 2001, as shown in Graph 7.
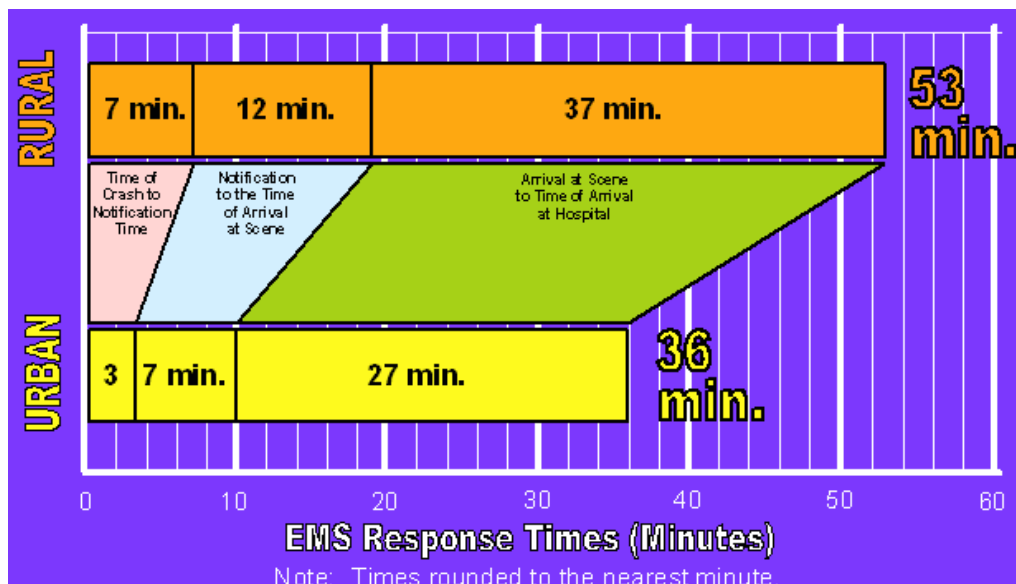
Graph 7: Comparison of Response Times in Rural and Urban Areas

2.4.1. EMS Time Response Scientific Analysis for Major Cities

Cities with Precise Time Response Measurements and Survival Rates

	Survival Rate	1st Responders Response Time	Advanced Life Support Response Time	Time to Shock
Seattle	45%	87% within six minutes	86% within ten minutes	78% within nine minutes
San Francisco	22%	90% within 7 minutes 30 seconds	90% within 8 minutes	N/A
Tucson	12%	82% within 6 minutes	93% within 10 minutes	N/A
San Diego	N/A	90% within 8 minutes	90% within 12 minutes	N/A

Cities with Imprecise Time Response Measurements and Survival Rates

	Survival Rate	1st Responders Response Time	Advanced Life Support Response Time	Time to Shock
Portland	49% arrive at hospital with pulse	90% within 6 minutes 30 seconds	90% within 6 minutes 30 seconds	90% within 9.61 minutes
Colorado Springs	6.4% arrive at hospital with pulse	4.86 minutes on average	7.02 minutes on average	6.6 minutes on average
San Jose	5.5% arrives at hospital with pulse	Contract with fire department require responses within eight minutes	Contract requires ALS units to respond within twelve minutes	N/A
Los Angeles	Currently studying	62% within six minutes	91% within ten minutes	N/A

2.4.2 Seattle Detailed Time Response Analysis

It has now been realized that Seattle, Washington has led the nation in 911 medical responses for decades. They created a unique system, but a system that is simple providing basic life – support services by firefighters trained as emergency technicians. The advanced care is handled by the paramedics, and their citizens participate by making efforts to save lives as well. The local ambulance system is "based on a medical model," said Michele Plorde, a section manager for strategic planning and data management at King County Emergency Medical Services, which includes Seattle and surrounding communities. "The design flowed from wanting to best serve patients with an appropriate amount of care (Doyle)."Seattle has managed a different approach to saving people that are in medical need. Seattle firefighters take pride in getting quickly to the scene of a medical emergency and as soon as they get to the scene they are able to employ measures such as defibrillating a stalled heart with electrical shocks and blocking a hemorrhage. All Seattle's firefighters are trained as emergency medical technicians who can provide the basic skills to help someone that is in need. "We do things a little differently from most other cities around the country," said Bill Hepburn (Doyle), Seattle's assistant fire chief for operations. "Seattle is a city that probably has the fewest paramedics on duty in the country. The system has been here so long that if someone wants to come into the Fire Department just to go to fires, they've come to the wrong place (Doyle)." With fewer paramedics than San Francisco, Seattle does not station them on fire engines; they are assigned to two-person ambulances. They are used sparingly to help those in need of advanced care such as special medications and intubation in cardiac arrest cases. "Our paramedics are not assigned to a fire engine

because it waters down their skills," said Plorde, adding that King County's paramedics

work in pairs. "We try to concentrate their response (Doyle)."

Figure 6 (MapQuest, Seattle)

2.4.3 Seattle: EMS Response System Major Breakthrough

Seattle has reached a superior result by having the highest survival rate for cardiac

arrest cases among larger U.S. cities and this is solely due to the fact of their unique

creation. Statistically Seattle are known for, "saving forty-one percent of those in 2006 who

went into ventricular fibrillation, a type of sudden cardiac arrest characterized by a rapid,

irregular heart rhythm (Doyle)." These very patients were able to depart from the hospital,

and while leaving they left with full neurological function intact. Other cities compared to

Seattle have fell short in rescuing people's lives. "By contrast, San Francisco's cardiac-

survival rate was 17 percent in 2004, when fire officials stopped tracking cardiac arrest data

as a result of budget concerns (Doyle)."

Across the nation, Seattle has become role models for many large cities in the United States. "No one has been able to emulate the (cardiac) survival rates that Seattle has published, and in fact some people have questioned them," said Dr. Jim Pointer, medical director for Alameda County's office of emergency medical services. "But we ought to be trying to emulate them. For cardiac arrest cases, it means getting there quickly, providing effective CPR and early defibrillation." Seattle have taken an initiative to quickly respond to emergency calls because the key to saving someone's life if serving the patient as soon as possible. "Without immediate medical treatment, cardiac arrest can cause sudden death, and brain damage can occur in 4 to 6 minutes (Davis)."

The system in Seattle, which has the best lifesaving rate among the nation's largest cities, is designed to keep paramedics away from the lesser emergencies and keep them available for the true life-or-death calls. If firefighters get to the location and find the person is not breathing, Poole says, they can call for a medic unit. "They have oxygen and a defibrillator, so they can give her what she needs before the unit gets there," he says (Davis). These are some examples of why Seattle have been so successful:

2.4.3.1 Cornerstones of EMS Response System

• A structure that from the beginning blended the fire department and ambulance services. There never has been a separation of the two.

• A strict policy of meticulously measuring the performance of the system, chiefly by monitoring sudden cardiac arrest survival, one of the truest measures of an emergency medical system's success.

• Strong leadership from the start (Davis).

2.4.3.2 Fire vs. Medical Calls in Seattle: An Analysis

Fire vs. medical calls: Seattle

Firefighters in Washington respond faster to fires than to medical emergencies.

■ Cumulative percentage of fire calls reached within:
□ Cumulative percentage of medical calls reached within:

Less than 1 minute
0.5%
0.5%

1-2 minutes
2.2%
5.3%

2-3 minutes
15.5%
28.3%

3-4 minutes
40.0%
58.1%

4-5 minutes
61.3%
77.8%

5-6 minutes
75.4%
87.6%

Source: USA TODAY survey of emergency medical systems in the nation's 50 largest cities
Graphic: Robert W. Ahrens, USA TODAY

Figure 7: Fire vs Medical Calls and Response

As the figure shows, firefighters respond more rapidly over the paramedic units. And this graph specifically explains how it is done in Seattle. In other cities, firefighters are always responding faster than the EMS units. This is because firefighters have fewer supplies to maintain, unlike the paramedics who have to be concerned about the amount of drugs available for any severely needed patient. Seattle's plan to give basic medical training to firefighters has benefitted their city and also has influenced many big cities.

2.5 Foreign Country Ambulatory Time Response Analysis: United Kingdom

The United Kingdom has a number of principles which form the foundation of their EMS Systems. These have become guidelines over the years which if not followed could lead to sanctions and severe punishment (in case of improper handling of mass

26

disasters and catastrophes). Since the last two decades, they have narrowed these guidelines to factors they call High Impact Changes –HIC- (named appropriately due to the vast effects they can have on EMS functioning). The improvement philosophy behind the concept of High Impact Changes initiates from the principle that ambulance service operations need to be designed not only to avoid performance failure, but also to enable continuous improvement across the whole organization.

2.5.1 Improving Ambulance Response Times: High Impact Changes

Following are the components of this improvement philosophy –

1. System should be designed to improve continuously,

2. Take a detailed process view of the flow of calls and patients across

EMS (departmental/organizational boundaries).

3. Working smarter not harder

4. Focusing on bottlenecks (weakest assets) of the EMS System.

5. Manage and Reduce causes behind Performance Variations.

6. Classifying patients according to Medical needs and not Socio-Economic Factors.

7. Implement Benchmarks to measure the true performance of the system in real time.

Now, we move towards the more important and direct factors that we termed "High Impact Changes". They include both operational and control room based changes, developed for real and sustained improvement in performance and patient care. Some of these changes are independent; in that they stand alone in terms of delivery; others are dependent on one or more changes and require planned implementation that takes longer time and involves higher (more sustained) levels of management. UK also stresses on developing any EMS Management System keeping in mind the Emergency Call System in

place so the implementation of the new ideas is smooth and apt. For every HIC, we have also included some best practices which give an insightful example of application of an HIC by EMS Teams. Following is a comprehensive listing of the HICs:

2.5.1.1 Ownership of performance by key managers

Ownership of performance by key managers – This is useful because it allows "on the day" management of performance. It also ensures ownership of problems, and rapid implementation of corrective action. Daily/ weekly briefings are held. Every morning a telephone conference is held to discuss previous day's performance and also to plan actions for the current day. Personnel are also held accountable for non-delivery of agreed actions. Real-time performance information is available to key managers. Messages are generated automatically by the CAD system, (at least four times a day) and sent to a pager or mobile phone (by SMS).

Best practice – The South East Coast Ambulance Service in London, United Kingdom has an internet based performance and activity reporting and monitoring tool. This lets the ambulance service to focus on individual/specific station, PCT, postcode, dispatch level and review their performance and activity. This data is then transferred to larger and more accessible national level server.

2.5.1.2 Effective Staff Management

Effective Staff Management – This optimizes a center's ability to realize a robust and sustained performance improvement. Personnel calling out sick should be maintained at less than 5% of all operational staff at all times. Annual leaves of different employees must be managed and synchronized during the Christmas and New Year periods.

Best Practice - After a critical report by The Healthcare Commission of the Kent sector, the local EMS authorities embarked upon a route of service and performance improvement. A thorough clinical governance and performance improvement plan was developed by the Executive Team and agreed upon by staff-side representatives. A Risk management and clinical governance committee was one of number of changes proposed by the plan. Responsibilities of every member on the Board or EMS Executive Staff was revised and updated. It was a challenge for the new plan to completely replace the one that the Report had found faulty. This was because the Commissioners did not see the sudden budget demands coming. A State-Sector joint approach made this possible.

2.5.1.3 Dynamic deployment plans

Dynamic Deployment Plans - Dynamic deployment is a common term used in ambulance services. Simply put, it refers to the practice of moving resources (machine and man) closer to the predicted source of the next call. It includes a combination of locations and ambulances on standby near those locations. Locations and predicted demand show clear co-relation; location varies over longer periods (months or years). Resource deployment is much quicker from standby positions, and this along with its current location may improve response times. Resources also have to be distributed in strategic standby to areas of predicted high demand. It is equally necessary to identify standby points, segregating between those to be used on a regular basis and ones that may be used only temporarily. These plans must take into consideration factors like traffic flows, location of facilities etc. Also, the Plan should not include more than 20 resources per dispatch desk. At all times, communication with front-line personnel is essential to

ensure understanding of the process and letting them have a say when developing and implementing plans.

Best practice - East England Ambulance Service in Bedfordshire and Hertfordshire sectors use the MIS Alert 2000 CAD system. This deployment plan has been developed by carrying out local demand analysis on the basis of historic data collected for well over 25 years now. Demand analysis is carried out at least thrice a year to review and make any required changes. The plan is built into the CAD deployment system and automatically activates an ambulance or response vehicle to move to the closest standby position.

2.5.1.4 Development of a front-loaded model

Development of a front-loaded model - Fast-response vehicles and co-responder schemes are being developed to get to the scene faster than traditional ambulances. They also provide potentially life-saving assessment and care until back-up arrives. "Front-loaded model" is an expression that refers to a decrease in the proportion of traditional ambulances in a fleet and an increase in the proportion of fast-response vehicles. Furthermore, a fast-response vehicle with a paramedic or ECP on board may prevent the need for a traditional ambulance, as some vehicles already transport patients to hospital or other care facility. Community co-responder schemes should first be implemented in areas where the 8 minute ambulance response time benchmark is difficult due to the geography (isolation of the area or if area has low demand levels.) It must be noted however that these schemes are not a substitute for an ambulance response and dispatch of the two responses should be concurrent. Sending a single response rather than both to appropriate Category A calls (immediate life-threatening) frees up resources for other calls and helps

to maximize performance. Deployment of FRVs(Fast Response Vehicles) needs to be quick and simple. Modern CAD systems allow the auto-paging of community/ co-responders when a call is received in the area that the scheme covers. Adequate training of community/ co-responder schemes is necessary to ensure that they are not sent to calls that are beyond their competence to deal with. Particularly, operational staff will have to be assured that during implementation of the scheme; support from key managers is available to them as and when required. All training must deal with identifying appropriate call codes and flagging them on the CAD. Effective staff side engagement is also an important and critical aspect that should be addressed. Best practice – EMS Services have been assigning significantly different amount of resources for 999 calls in almost every major UK Sector. This as discussed above is known as the "front loaded model" and is a term used to describe a planned decrease in the number of front-line double staffed ambulances deployed to a call and a significant increase in the number of single staff response vehicles, capable of carrying patients. This model has workforce implications for ambulance services and will take over several months to be implemented. Dispatchers in 911 call centers also have to be re-trained in the deployment of more single responders. An operational synopsis of what issues ambulance centers might face when they start implementing the front loaded model is currently in place.

Best practice (2) - West Midlands Ambulance Service has introduced a Solo Responder Back up Procedure. This has now been agreed upon by the staff and is functional presently. It works by not automatically sending a backup response to a First Contact Practitioner or Paramedic when responding to a Category A call unless specific criteria are met. For example, young children, patients exposed to the elements, seriousness of patient condition, health and safety issues – for staff and/or patient; may all mean that a backup

response is dispatched. This procedure will go hand-in-hand with the introduction of the front loaded model.

2.5.1.5 Effective matching of resources to demand

Effective matching of resources to demand - This is a basic requirement of achieving performance. Having correct rosters in place, which reflect demand patterns, ensures that there is capacity to provide a rapid response and that efficient use is made of resources. Varying rosters reflect seasonal fluctuations in demand. Mix of different start and finish times, varying shift lengths to meet demand and to manage impact of shift handover periods. Review rosters twice yearly to check continued appropriateness. This change can be complex and time-consuming to implement. Changes need to be owned by staff and therefore early engagement with staff and unions is essential. Some services have centralized roistering through PROMIS, while other services have encouraged self-roistering through self-managed teams of eleven or twelve staff.

Best practice - In the East Midlands Ambulance Service, the Lincolnshire sector has developed the concept of self-managed teams. Through a team leader with a dedicated team of Technicians and Paramedics, they arrange to cover annual leave, sickness and training from within each team. The teams work on the basis of annualized hours and Working Time Directive software suggests a number of roster options, which match demand, for the teams to consider. The self-managed teams' concept has been very successful and the Trust is proposing to roll this out to other sectors, which may include the control room.

2.5.1.6 Demand analysis

Demand analysis - Understanding of historical and current demand and use of data to predict demand and plan capacity underpins an effective high performance regime. Systems and processes in place to be able to identify quickly peaks and troughs in performance and understand the causes of deviation to enable corrective action to be taken. Agreed minimum dataset provides daily critical performance information to key managers. The data analysis team has the ability to undertake rapid analysis of performance information and is able to present the findings in operational terms. The use of software provides modeling around demand/dispersion patterns and distribution. Use the DH ambulance reporting tool to understand demand and barriers to improvement. Quarterly demand capacity planning reviews. Bi-annually review demand, performance arrangements and dispersion of activity. Prepare separate capacity plans for known peak periods of demand such as summer holidays, winter, bank holidays, Christmas and New Year. Involve out of hours services, A&E departments, urgent care networks and PCTs in developing the plans to ensure that the impact upon other services is realized and managed, and to consider alternative care pathways. Best Practice - The Mersey sector of the North West Ambulance Service has developed a performance dashboard. The dashboard works by importing live data from the CAD system into the dashboard on an hourly basis and provides reports to managers around performance and activity for their operational area. The Trust also believes that the dashboard is helping them to understand much more about the changes that need to take place in the control room to support the introduction of call connect. On each Monday morning Operational Managers review with staff the performance issues and test with them the effectiveness of any changes that have been made. This information then forms a major part of the sector performance plan which

is discussed at the weekly meeting of Area Managers, chaired by the Head of Service. The performance issues are then fed into the Executive Team which meets every Tuesday afternoon. At the weekly meeting Managers are held to account by the Head of Service for implementing any changes agreed at the last meeting.

2.5.1.7 Control room awareness and ownership of individual and collective performance

Control room awareness and ownership of individual and collective performance - Creates awareness of current position and encourages improvement. It enables individual and team performance to be managed. Using new technology to measure the performance of Control Room Supervisors/Managers and call takers and dispatchers. Category A, B, C, GP urgent and call answering times should be displayed linked to the CAD for real-time data. A separate display should also be available showing incoming 999 calls awaiting dispatch. A display board showing 999 call pick-ups, call waiting, calls lost per shift. All managers able to access this information electronically. Be clear about expectations around individual and team performance. Manage variations in individual performance from norm/best practice.

Best practice - West Midlands Ambulance Service has developed local performance indicators for control room staff. Call pick up information is updated every 15 minutes and this enables the duty supervisor to post performance on a white board every hour, showing the position as at midnight, week to date and year to date. The four teams of call takers and dispatchers are measured on the activation of resources for Category A8/ A19/ B19/ Urgent and Category C performance. This is also plotted on a chart and forms a part of the performance review process for supervisors, call takers and Dispatchers.

2.5.3 Call Management Cycle for various Models

Call Management Cycle for various Models - The call management cycle times set out below are an average only, and have been used in various pieces of operational research carried out in a range of British and American ambulance trusts for modeling the performance changes required to achieve response time standards with call connect in place.

The Traditional Service Model – average best practice times for benchmarking purposes

1. Call connect to call answer = 5 seconds

2. Call answer to vehicle assigned = 55 seconds

3. Vehicle assigned to vehicle mobile = 30 seconds

4. Call connect to vehicle mobile = 90 seconds

The Front Loaded Model (FLM) average best practice times

1. Call connect to call answer = 5 seconds

2. Call answer to vehicle assigned = 35 seconds

3. Vehicle assigned to vehicle mobile = 20 seconds

4. Call connect to vehicle mobile = 60 seconds

The turnaround times at a healthcare facility

The time between the arrival of an ambulance transporting emergency or urgent patients to a healthcare facility (vehicle arrival) and the vehicle becoming available again to respond to 999 calls (vehicle clear) should be on average 15 minutes. This is known as the turnaround time.

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again to respond to 999 calls (vehicle clear) should be on average 15 minutes. This is known as the turnaround time. The clock for measuring waiting times in A&E departments should start 15 minutes after vehicle arrival, whether or not the ambulance crew has handed over that patient to the care of the A&E department. On the basis of performance modeling work carried out in the majority if ambulance trusts in England, it has been found that the best practice on-scene times for First Response Vehicles (FRVs) and ambulances under both models are as follows:

Traditional model – 15-20 minutes (FRVs and ambulances) Front loaded model – 30 minutes (FRVs).

Figure 8: EMS Response Time Break-Up and Mechanism

2.6 Conclusion

From the analysis in this chapter, it is clearly visible that there are some flaws in the EMSs' system and/or in the telecommunications. These telecommunications help in providing the valuable data that EMS officials need in order to reach the patient in need, as soon as possible. These technological improvements and integration into the EMSs in the United States are further discussed in the next chapter.

CHAPTER 3. SOLUTIONS TO AMELIORATING TIME RESPONSE

3. Introduction

From our research of various US states and countries around the world it is clear that although the standard response time is set to be eight minutes, for most of EMS the response time is higher than eight minutes. In the US, for urban areas 72% emergency calls EMS response times are about 12 minutes. This response time is even worse in rural areas and in third world countries this number is unimaginable. Since the purpose of this project is to improve the EMS systems in Massachusetts and other US states by looking at various local and global factors, we will be looking at ways to improve the EMS systems first in different Massachusetts cities including Worcester, Boston and how they can be implemented in other developed countries. Due to various barriers such as poor traffic laws reinforcement, economical structure as well as other factors that exist in third world countries and that can't be related in terms of developed countries and this project we will disregard the developing countries.

From our research it is evident that technologies can play a significant role in improving time response system in the US. Although the technologies that can help improve the response time in EMS system already exist today, most of the states including Massachusetts lack the proper implementation of these technologies. These technologies can help improve the EMS response time as well as reduce traffic collisions due to emergency vehicles or situations, improve the decision making of the EMS dispatchers and reduce the non-emergency related calls making it easier for emergency responders on truly critical situations. The technologies that can prove to be helpful in improving time response for EMS are:

• Opticom System

• Operational consideration (color system for the dispatchers, communication technologies)

• Implementation of 311 call system

• Usage of Q-CPR

• Ultrasound in Ambulance

• Philips Periodic Clinical Data Transmission system

• AACN

• NG-911

• Integration of M-PC and OnStar

• Tabu Search

In this paper we will discuss these various technologies as well as how their usage can improve the response time as well as other factors that were mentioned above.

3.1 Opticom System

One of the major technological equipment that can be implemented in improving response time is the installation of Opticom system which is already being used in Burnaby, British Columbia; San Francisco, California; and Portland, Oregon.When the Opticom GPS system is installed in the traffic system at an intersection it allows Police and fire department vehicles to activate specific traffic signals from a great distance. This helps to clear up traffic allowing the emergency vehicles to pass through at a faster and safer rate.With this Opticom system, each vehicle is equipped with transponder equipment that sends secure radio signals to a phase selector at specified intersections. As a result, the police and fire personnel can activate a priority green signal to ease up congested traffic areas and drive quickly through intersections and traffic areas upon their arrivals. Since these GPSs do not require line in sight activation and they use radio frequency signals can be triggered at any moment as necessary with consistency. What's even better about this system is that a traffic engineer always has access to Opticom

software which lets the engineer monitor any traffic signal preemption at any intersection at any given instant and when maintenance is required for any system at an intersection an email will be generated so that the engineer can pinpoint the problem.

It is clear that Opticom can be huge reinforcement in order to improve the EMS response system. But it can be developed further by placing it into ambulances along with police and firefighters. This will give EMS responders more control over the traffic system whenever there is an emergency. Thus by implementing the Opticom Infrared System along with its GPS system dramatically improves safety at intersections while minimizing traffic disruptions, accelerating emergency response times and improving transit service reliability.

3.2 Operational consideration (color system for the dispatchers, communication technologies)

As suggested in the previous part of the paper using cue summation theory can lead to a huge improvement in EMS dispatchers' decision making complexity. What we suggest is this: In current EMS dispatch system, dispatchers sort the calls by various coding system when calls are received. Using color coding system dispatchers will have various codes to sort and prioritize these emergency calls. For example: color red can be for trauma, cardiac arrest or severe emergencies like those; for moderate emergencies such as broken legs, bones etc. colors from orange and yellow can be used; for non-emergency situations such as minor cuts, sore throat etc. colors such as green, blue etc. can be used. Using the colors can help dispatchers make quick decisions instead of going through codes and trying to decide which case is severe and which is not. Besides that, each city can be divided up to certain are EMS system. Each area EMS personnel will have inexpensive version of iPod touch like device which will be able to utilize any carrier's cell phone and data signal. In case an EMS area is located where there isn't any cell phone connection traditional EMS connection system will be used. When a call is

received, that city area and surrounding city area EMSs will be notified. Whoever is closed to the emergency site will be responsible to be report to the site and that responding EMS system will notify the other EMS systems that they are reporting to the site. This way response time will decrease as the need for dispatcher to find and assign an EMS system will be eliminated, but this will require some initiative from EMS personnel which needs to be incorporated as part of their EMS training.

3.3 Implementation of 311 call system

Another effective and low cost solution could be the implementation of 311 call systems along with the 911 emergency call system. In various part of the world this 311 call system is being used effectively. In order to make this 311 call system a successful people have to be taught the differences between 911 and 311 calls. A school based education program can be launched so young children will be taught how to differentiate and make the correct decision while calling the emergency responders. Commercials on TV, internet, subways etc can be used to teach people how to use this system effectively. If 311 call system is implemented, 911 will be used in terms of severe and life threatening emergencies such as accidents, fire, robbery, criminal activities, cardiac attack, trauma. For non-life threatening injuries such as cut, toothache, slip and fall, minor fever, sore throat etc.

3.4 Usage of Q-CPR, Ultrasound in Ambulance

For an effective EMS system, Q-CPR can be installed in the ambulances. Q-CPR is a more proven modern CPR technology compared to traditional CPR devices.According to Philips, " Q-CPR is available as a fully integrated option with the HeartStart MRx Monitor/ Defibrillator and offers several vital advances, based on the latest research, and input from current Q-CPR users." This Q-CPR delivers instant audiovisual feedback of compression depth

and rate, complete chest recoil, hands-off time and ventilation rate. This can help an EMT make quick decision while trying to review a patient in critical situation. Implementing this device will not only help EMTs, it will also save valuable lives.

According to Dr. Jullette Saussy , director of New Orleans EMS department implementation of ultrasound in ambulances can turn out to be helpful and can help thousands of lives. Ultrasound can help provide a quick detection of cardiac arrest, trouble with pregnancy, trauma, and tamponade. According to National Center for Biotechnology Information (NCBI) "At present there is the need for a means of differentiating between various causes of cardiac arrest, which are not a direct result of a primary ventricular arrhythmia…. incorporating ultrasound to manage cardiac arrest aids in the diagnosis of the most common and easily reversible causes of cardiac arrest not caused by primary ventricular arrhythmia, namely; severe hypervolemia, tension pneumothorax, cardiac tamponade, and massive pulmonary embolus." Thus it is easily visible what an important role ultrasound could play in critical situations and what a tremendous help it would be to the EMTs.

3.5 Philips Periodic Clinical Data Transmission system

The HeartStart Telemedicine system by Philips can also be used to connect the EMTs to doctors. This system provides critical data to doctors ahead of patient arrival at the hospitals in case of critical situations such as strokes, cardiac arrests, trauma etc. Thus the system enables a better communication between EMS and the care providing doctors. This also helps doctors make better decision and communicate the information to the EMTs in case the patients need certain type of care on their way to the hospital. This enables EMTs to focus on patient care instead of focusing on whether the data is being sent to appropriate hospital or not. The quicker data transfer can also help EMTs get back to next patient since the responsible doctor will be prepared for the patient. Besides EMTs this helps doctors make a better decision based on the patients' symptoms. It also enables emergency care doctor to summon specialists

(or rule out), or pull patient histories in parallel with incoming transport. Advance objective

data can also help with better utilization of valuable resources in the Lab, Surgery, and ICU.

3.6 Advanced Automatic Collision Notification

Advanced Automatic Collision Notification (AACN), also known as Advanced

Automatic Crash Notification, is a technology that is implemented in motorized vehicles. This

technology is available in very few vehicles around the world. The technology works in such a

way that it eliminates the necessity for the person in need of help to call the emergency medical

services for assistance. When a vehicle is involved in an accident, the injured individuals are at

times incapable calling for assistance. Other individuals around the accident scene have to be

responsible enough to make the call. Therefore the fastest and safest bet to report the accident

to emergency services is through an automated system. This is where the AACN comes into

play. The AACN is able to make contact with the dispatch center within milliseconds of the

crash. This is how a general AACN system operates. There are 3 major components; the

sensors, the module, and the antenna. Seen in the figure below.

Figure 9: AACN System
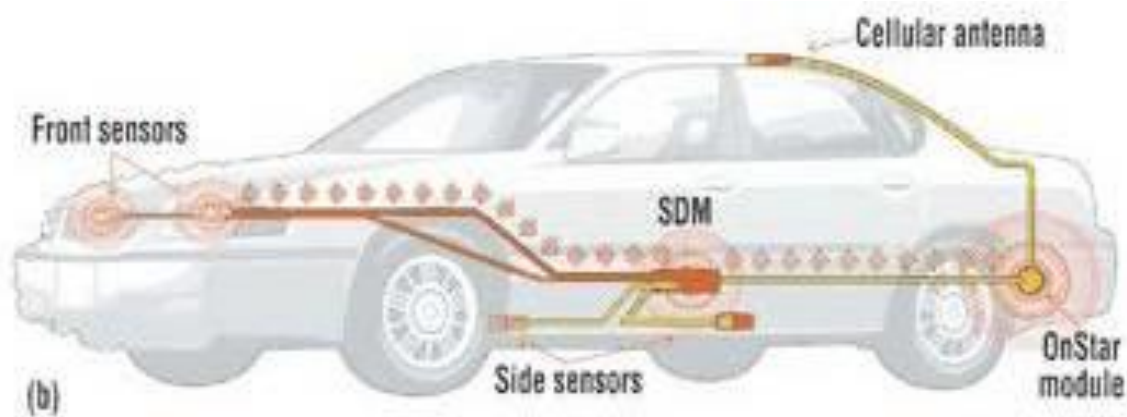
When the vehicle is involved in a crash, the sensors are able to pick up the essential data from

the crash, which is then wirelessly transferred to a Public Safety Answering Point (PSAP).

These sensors help activate the collision notification. As seen from the figure, the cellular antenna helps communicate the information to various sources. This information includes the speed, delta velocity, direction of forces exerted on the vehicle during the crash, vehicle heading, final resting position of the vehicle, vehicle occupants, seat belt use by occupants, roll over information, and the GPS location of the crash. Each AACN device has a unique ID that matches a vehicle profile. This profile identifies the vehicle owners, or in this case, the public safety agency, to which the vehicle belongs. This vehicle database also contains information including the color, make, model, vehicle identification number, license plate number and emergency contact information relevant to the owner. Specific medical data can also be part of a database. The vehicle owners, or likely vehicle occupants, medical history, medical conditions, allergies, blood types, or other needs can be passed on to the emergency responders. Once PSAP has access to all this information, it can share it with necessary correspondents like, the EMS or the closest hospital. AACN processes the information from the crash site and allows its calls to be transferred to the closest PSAP. Using its GPS location, received from the vehicle, the PSAP is electronically able to notify the EMS the data received from the AACN. This entire process usually takes under eight seconds and requires little human intervention. Whereas, if this technology were not under existence, this entire process could have taken anywhere between 20 seconds to several minutes and much less details would be known about the severity of the accident and the injured individuals. Tests have shown that 99.8% of the calls are successfully completed and teh remaining are manually dialed up by the backup network. EMS and other electronic companies have joined hands since 2001, and have been able to implement the Automatic Collision Notification (ACN). The Advanced ACN is a much newer technology and is harder to implement. This requires car companies, such as Ford, GM, Toyota, Honda, Nissan, etc., to start the production of new cars with the AACN system built in to the model. These cars will also be more expensive therefore less consumer friendly.

The time it will take for majority of the population in the US to adapt to this technology might take close to a decade, and by that time newer technology will have come out.

The way to attack this problem is through proper management and production of the new cars with the built in AACN system. One solution could be to have the AACN available as mobile devices. If the AACN modules are just produced as separate consumer products, they could be hooked up electronically to the car antenna and the air bag or the car bumpers. This way if there is an accident the deployment of the airbag will activate the AACN module, which in turn will send a signal through the antenna to the necessary PSAP. Just like the seat belt law, the AACN modules could also become a law. For this to be possible, the AACN modules have to be sold at a low price. Producers will only be able to do this if the government is able to subsidize on their production. One problem to overcome would be the false activation of the AACN system. Like every wireless device, there are risks of false activation. A small bump or an object hitting a immobile car might activate the AACN system and notify the PSAP to send help at the location. This would result in wastage of resources when it could be put to better use and more efficient use. One solution to this would be to have a manual deactivation button in the car or on the module. Since the device could also fail in activating the notification when the car is in a crash, it would also be reasonable to have an activation button.

A similar product is already available in the European Union. It's known as the eCall. The eCall uses telematics technology and an AACN system to wirelessly deploy airbags and send sensor information and GPS coordinates of the black box. This AACN system uses a black box, also formally known as train event recorder. A black box basically records all of the electronic data within the vehicle, for example its speed, acceleration, wind speed, temperature of the engine, force of collision, and much more. This information will be helpful to the PSAP and EMS to assess the severity of the collision and necessity for help. The project is also supported by the European Automobile Manufacturers Association (ACEA), an interest group

of European car, bus, and truck manufacturers, such as Toyota, BMW, Volkswagen Group, Volvo, Ford, DAF, Renault, Fiat Group, Scania AB, Porsche, Mercedes, PSA Peugeot Citroën, and MAN AG. ERTICO is Europe's Intelligent Transportation System (ITS). Many of the stakeholder companies involved with telematics technology have membership in ERTICO or ACEA. An advantage of this membership is increased ability to influence developing eCall standards.

3.7 NG-911

NG-911, also known as Next Generation 911, is a project being undertaken by the United States and Canada. Its service is not in place, but overtime its plan will be to replace the existing 911 protocols. The NG-911 aims at improving the infrastructure of the public emergency communications services. The NG-911 vision relies on an Emergency Services IP Network (ESInet) to deliver voice, video, text and necessary information to the PSAP. In order for a useful connection to be made between the PSAP and the person reporting the emergency, a number of changes need to be made to the existing infrastructure. For example, if a user is sending a text message, perhaps with video attached, the data needs to be routed to the PSAP that serves the area where the person is currently, and the location of the wireless device must accompany the message. The person's wireless carrier will receive the message first, and then forward the message to the appropriate PSAP along with the location information. A High availability IP infrastructure interface will be needed at the PSAP for it to be able to send and receive all this data. A key element of this will be equipment and software to support Voice Over IP (VOIP) communications. Internal routing of the emergency communications to the appropriate systems will require modifications to the existing PSAP network equipment and software. Some of these changes will be non-trivial. Since some of the emergency communications data will have to be forwarded to field units such as police and fire vehicles,

changes will be required to the software running on the terminals that receive the data, and on those that transmit the data. The NG 9-1-1 test plan requires that these new types of emergency communications (text, pictures, and video) be recorded along with the voice communications that have traditionally been recorded. Most existing communications recorders are not capable of recording anything other than audio, and major changes may be required to bring these devices into NG9-1-1 compliance. This may require a significant investment on the part of the PSAP if the existing equipment cannot be modified to support the new requirements. There will also be significant operational impacts on the PSAP "call takers", dispatchers, and on their managers. Workloads are expected to increase, and significant new training will be required for those responsible for responding to these new communication types. Similar impacts on both public and private emergency response providers and on Telematics and medical services providers are also anticipated. A problem with NG-911 is that various features like, text-messaging and picture messaging are not accessible features for those who use a regular telephone. The new world is transforming its self to using more and more smart phone technology.

The AACN and NG-911 systems must be tightly integrated into the overall emergency system in order to effectively initiate the chain of events that will increase a crash victim's chance of survival.

3.8 Integration of M-PC and OnStar

Ambulance time response is becoming a crucial topic in nearly every part of the world. The importance to reach to a particular patient in a timely manner has to be improved and the way it should be improved is by integrating new technologies. Many countries are looking for ways to improve ambulance response times through technology. Europe has drastically developed and researched on devices that can improve the crisis on ambulance time response.

Östergötland Ambulance Service helps provide the pre-hospital care in the Linköping

metropolis, which is an area on the southern half of Sweden. Around this area it has been

recorded to serve as a hospital catchment for 420,000 citizens and on average the service

typically responds to 40,000 incidents on a yearly basis. The Östergötland Ambulance Service

had to face some challenges before implementing any devices to their vehicles. The ambulance

service first needed to spend a great deal of money on IT support systems. The support of IT

systems allows emergency care personnel to improve control and response capabilities on

emergency callouts. There are numerous restrictions and demands that had to be met. One of

the primarily restriction and demand was that the IT support system developed, had to

completely involved with the methods used locally for pre-hospital command and control and

their pre-hospital trauma life support system. Another major demand would have to include the

system to be web-based.

The solution that has been developed is known as the Microbus M-PC. The project was

a part of Saab Performit's Paratus' and Saab was chosen by Microbus M-PC. Europe has

begun to excel on the technological advances to improve time response. Microbus in-vehicle

computers have brought a whole new experience into the ambulance market across Europe and

their comprehensive installations have improved the functioning effectiveness and, therefore,

have brought forth for faster emergency response times in Europe. In Figure 9, you can see

how the M-PC monitor is mounted within an ambulance.

Figure 10: Driver Access to a M-PC

The M-PC's key criteria are portrayed in its high performance and advanced feature-set. It has proven to demonstrate in the ambulance to be functional and flexible. This device has also offered the user a full desktop PC capability, the Microbus M-PC provides greater connectivity for peripherals within the vehicle, integrated design to support optimal positioning of the antenna to receive the best coverage and the most precise GPS positioning. Below in Figure 10 you can see an example of the M-PC within the dashboard of a vehicle.

Figure 11: M-PC in a Vehicle

Figure 12: Electric Board of the M-PCAttached to the Vehicle

The image above provides a visual of how the M-PC is installed within the back of the

vehicle. As you can the M-PC is powered by two power plugs and consists of the essentials

of any modern PC. This system is equipped with an Intel Core Duo processor, offering

leading performance and greater energy efficiency. The cameras include a dedicated

MPEG channel to support Digital Video Recording. This particular system is the M-PC3

series. The components consist of features such as: Automatic Number Plate Recognition,

Digital Video Recording, database access, Computer Aided Dispatch, incident reporting

and GIS/Mapping.

The ambulances that have the M-PC installed have the ability of in- vehicle

computer driving a dual touch screen solution, which significantly benefits the ambulance

users, enabling dual progression of different functions instantaneously improving

efficiencies and overall affects the speed of response times. As the vehicle receives a

callout, it is displayed on the touchscreen and the important details are sent out by the

dispatcher while received on the screen in plain text. The computer provides the most

accurate route to the scene with its navigation instructions for the driver through its digital mapping system. Once the ambulance reaches the destination it does another unique thing by sending out a status report to the Command and Control Centre. The new IT system provides better emergency care for Östergötland Ambulance Service this involves the latest updates on GPS coordinates, so the system is allowed to be revised and help any other emergency vehicles on their way to the precise location where ever the emergency help is needed. The personnel also have the privilege to carry out an assessment of the situation with the aid of the computer.

The key advantages are precision and the fact that the notes are complete by the time the patient arrives at the emergency department. Then all that remains to be done is to check them for accuracy and sign them off. "Another advantage of the system is that it has an interface with the Swedish population register. This makes patient identification easier, and at some stage in the future it will be possible to download digital patient records from a national database (Leif Gustafsson, In Car PCs)."With the success of the M-PC, it provides both ambulance service and the emergency department substantial database of care response statistics for future use in analysis, planning and organizational decision-making.

The creativity and the engineering behind the M-PC greatly benefits ambulance response times, but it doesn't end there. The OnStar service primarily provides road side assistance by relying on CDMA mobile phone voice and data communication, such as Verizon Wireless in the United States and Bell Mobility in Canada, as well as tracking information by using GPS technology. OnStar services provide the driver and passengers' audio interface so everyone in the car has the capability to contact OnStar representatives for emergency services, like vehicle diagnostics and directions. The OnStar system is truly a valuable feature that can be added to any car, due to its connection to the OnStar call center. In the event of a severe car accident the Advanced Automatic Collision Notification feature goes off once it detects airbag

deployment. During this moment, the OnStar device instantly sends information about the vehicle's conditions and coordinates for GPS tracking to the OnStar call centers. Figure 12 below illustrates the procedure for OnStar.

Figure 13: OnStar in Diagram

The most important feature that consists within the technology of OnStar is that it can send an emergency notice to the OnStar service call center immediately after airbag deployment. After the OnStar call center has received the accident notice it sends the information to the dispatch and then the dispatcher sends it to the ambulance. Although, this OnStar service provides automobile accidents with better ambulance response time it still can be improved.

The TRACE group has developed a solution that can implement the ideas of the M-PC and the OnStar services together and form a better way to respond to automobile accidents in the United States, particularly in Massachusetts. To better the system in the most technological way is to combine the two systems. M-PC is essentially a computer system within an ambulance that is capable of receiving messages without the help of the dispatcher. OnStar services take up time to send the message to the OnStar call center and then forward it to the dispatch. The TRACE group has developed the idea to create a device similar to the OnStar, but directly send out a signal to the nearest available ambulance. An ambulance with the M-PC can immediately receive the code from the device in the automobile and

then generate the directions to the accident scene by using the computers advanced GPS navigation system.

3.9 Tabu Search

A dynamic model is proposed and a dynamic ambulance management system is described. This system incorporates a tabu search algorithm (specifically, a parallel Tabu Search) so the managers of emergency dispatch services can know beforehand how redeployment scenarios may look like. Simulations based on real-data will confirm the efficiency of the proposed approach in the future.

So, what is Tabu Search? Tabu search, created by Fred W. Glover and in 1986 and formalized in 1989, is a local search method used for mathematical optimization. Local searches take a potential solution to a problem and check its immediate neighbors (that is, solutions that are similar except for one or two minor details) in the hope of finding an improved solution. Local search methods have a tendency to become stuck in suboptimal regions or on plateaus where many solutions are equally fit. Tabu search enhances the performance of these techniques by using memory structures that describe the visited solutions or user-provided sets of rules. If a potential solution has been previously visited within a certain short-term period or if it has violated a rule, it is marked as "taboo" ("tabu" being a different spelling of the same word) so that the algorithm does not consider that possibility repeatedly.

Tabu Search is today used widely in a variety of fields – technical and managerial. For example, given a list of cities, is there a way to order that list to minimize the distance travelled while still visiting every city. Our application to the Ambulance Relocation will be along these lines. Why Tabu Search method for such an important management? - The main objective of emergency medical services (EMS) is to save lives but the potential of such systems to reduce

mortality is related to paramedics training and to the time needed by a paramedic team to arrive on scene, in other words Time Response. The former is controlled by factors outside the scope of this project report. The latter, however is the one and only focus of the report. In reality, the EMS and dispatch is faced with two major problems: Allocation, and Redeployment. Allocation means the process which decides which Ambulance will be sent to answer a 911 or other emergency medical call. The redeployment problem consists of relocating available ambulances to the potential location sites when calls are received. In other words, it is an ambulance location problem. Every ambulance is assigned such that it can provide adequate coverage. However, is this assignment the best? Can one say that with this assignment, one can expect an ambulance to utilize all its resources optimally? The answer is very simple – No. For this reason and others discussed later in the report, we make use of Tabu Search Method to ensure the maximum realistically possible utilization of Ambulance Resources and also ensuring mathematical maximums for area coverage by each Ambulance allotted to a specific sector (community, city or district).

In our approach, we consider two types of covering constraint. The absolute covering constraints require that all the demand be satisfied by an ambulance within r2 minutes, and the relative covering constraints state that a proportion ! of the total demand is also within r1 minutes of an ambulance (r2 > r1). This type of constraint is in agreement with the United States EMS Act of 1973 in which the standards are r1 = 10 minutes and != 0.95. In the city of Worcester and the state of Massachusetts the r1 " 10 minutes and ! " 0.95, which just means that Tabu Search will have results in accordance with the 1973 EMS Act.

The redeployment problem is different from the standard ambulance location problem. While location problems are usually solved at the strategic level among the decision making staff, redeployment problems are solved dynamically in real-time, as EMS managers must make almost instantaneous and simultaneous decisions relative to allocation and redeployment.

The current location of vehicles plays a key role in redeployment problems, but location problems are usually solved at the original ambulance distribution level. One must also consider practical hindrances such as:

1) a limited number of ambulances can be positioned at each site;

2) only a limited number of ambulances can be moved when a redeployment occurs;

3) vehicles moved in successive redeployments cannot be always the same;

4) repeated round trips between two location sites must be avoided;

5) long trips between the initial and final location sites must be avoided;

6) an assignment to a call should be avoided near the end of a working shift;

7) at the end of a shift, the ambulance has to be moved closer to the central service point where the vehicles are based;

8) the breaks of paramedic teams have to be taken into account.

In the model we propose deals with constraints 1 through 5. Functions developed would have the sole objective of maximizing the backup coverage demand which is essentially the proportion of the demand covered by at least two vehicles within a known radius, minus a relocation cost.

Our proposed system would allow real-time decisions to be made at both the 'allocation problem' level (determining which ambulance to send to a given call) and the 'redeployment problem' level. In Worcester, typically calls are categorized into 4 classes based on severity – urgent requiring multiple ambulances, urgent requiring one ambulance, less urgent and pending calls which are periodically revised to determine the necessity for ambulatory transport or care. The Tabu search fed with data/variables from local search and surveys can produce high quality solutions to tackle the redeployment problem. This algorithm is based on a sequential tabu search algorithm previously proposed for a static ambulance location (as an example, the Gendreau, Laporte and Semet model). While the sequential tabu

search algorithm is perfectly adequate for the static location problem, a more powerful tool is required for real-time problem solving where life or death decisions must be made in the space of a few seconds several times a day. This is where the power of parallel computing comes into play. To further speed up the decision process a solution methodology must be developed that takes advantage of the available time between consecutive calls by anticipating future decisions on the redeployment of the fleet. However, in most parallel computing applications, the effectiveness of the parallelization scheme is measured by comparing the time required by the parallel implementation of the algorithm at hand with that of a sequential implementation. This is known as speedup index. However, this index is better suited to static models such as the ones developed in past. Today, with the new core processing abilities of network processors and a dynamic algorithm running continuously to yield improved solutions make the index redundant.

This section is largely derived from the Tabu Search algorithm running for the city of Montreal, Canada where it was applied only for experimental reasons. However, the solutions indicate the vast advantages of Tabu. Results for the city of Montreal below are derived from the Tabu solutions only with basic inputs of population demographics and ambulance vehicle details. Results were later proven to be at least 18 percent more accurate (on the parallel computing system) than the current sequential algorithms in place. Simply put, the Tabu search method was 18 percent more effective in EMS operations than the current systems. This is without taking into consideration the immense ability to improve further in the near future.

Morning Call Distribution in the City of Montreal	
Period	Proportion of morning calls (in percentage)
5 AM – 6 AM	9
6 AM – 7 AM	11
7 AM – 8 AM	18
8 AM – 9 AM	19
9 AM – 10 AM	18
10 AM – 11 AM	13
11 AM – 12 PM	12

Population distribution in Montreal

Number of processors	Number of tabu search iterations	Average number of calls to tabu search heuristic between two calls
1	49,005	5.84
2	101,227	11.45
4	197,243	18.47
8	348,392	33.10
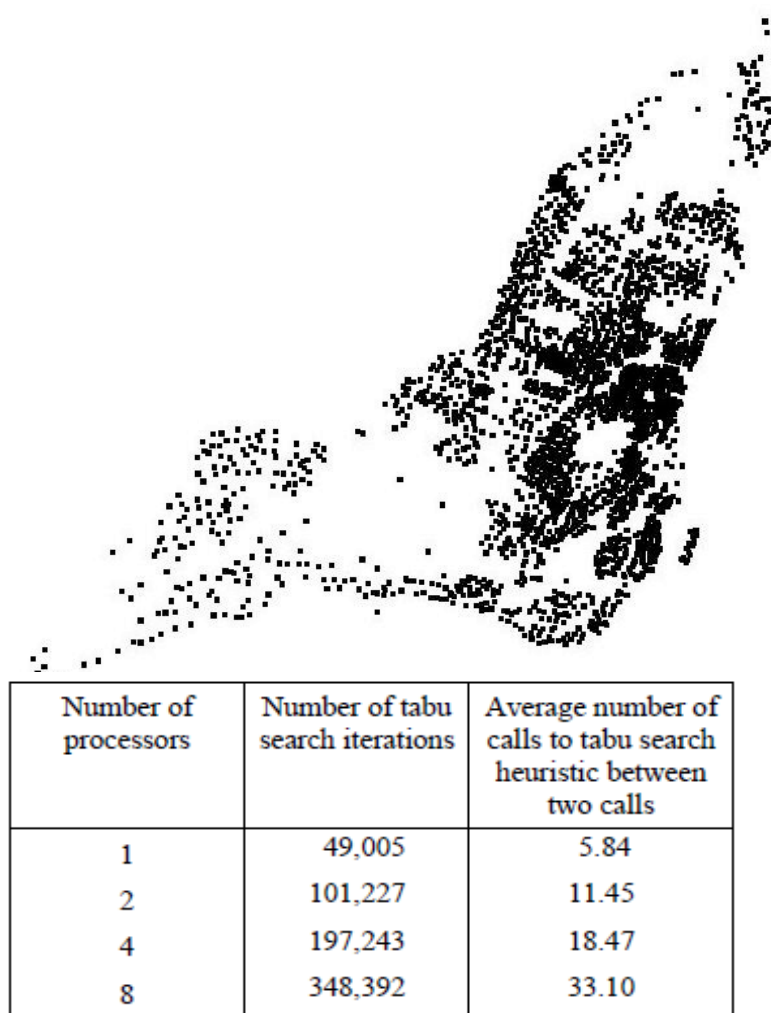
Figure 14: Tabu Search Analysis in Montreal, Canada

Conclusions regarding the Tabu Search and implementation for City of Worcester, MA– A dynamic ambulance dispatching and redeployment system such as this could be applied to Worcester. The biggest advantage lies in the fact that the pre-computation of redeployment scenarios will allow immediate decision making when calls are received.

3.10 Conclusion

This newly found idea developed by the TRACE IQP group can improve the time response. We believe these solutions can help improve the EMS response time all over the US. Implementing individual or combination of these solutions can contribute towards improved

patient care, save valuable time and lives. Finally, we encourage the development of EMS

Resource/Research Centers that will study the problems with the state wide EMS systems.

These centers will research up-to-date technologies that can be implemented in those specific

states' EMS systems based on that states' needs.

CHAPTER 4. CONCLUSION

This paper analyzes the complexities that exist in the emergency response systems and finds out how those complexities influence the response time and strategies of emergency personnel. Based on our research and findings, we suggest ways to improve the emergency response systems that exist in different parts of the country as well as parts of the world. The problems that were identified in the emergency systems varied based on the various regions that we looked at. We investigate the time responses in Texas, Detroit, Seattle, various North-East regions as well as United Kingdom and identified the problems that exist in the core of the emergency systems for regions mentioned above. Research supported our theory; that even with improving technology and medicine, the number of EMS calls made daily has been increasing throughout the years. In Rochester, NY alone the call volume has risen from 11,000 calls in 2004 to 18,000 calls in 2010. We see that population growth is not the core reason for the increase in call volumes as the city of Rochester experienced a constant negative population growth rate over a period of 11 years. We made a comparison between urban areas and sub-urban areas. We concluded that sub-urban areas, such as Rochester, experience high call volumes due to 3 main reasons: First, senior citizens tend to reside in sub-urban areas. Second, advanced medical care is not available, like in urban cities, and therefore residents delay their illness until an emergency, where and ambulance is required. Third, EMS systems in sub-urban communities act like a family tie. Trust is built between the medics and residents. We also saw that most of the calls made are 'Priority 1' calls, close to 80% of them. Priority 1 calls include cases such as cuts & burns, fractures, illness, etc. This leads to discussing the knowledge of the general public on topics such as when to call 9-1-1 and when not to. This is the solution on the residents' side to help ameliorate time response as fewer calls will be needed to tend to and therefore more time for patients who actually need it. Texas, one of the biggest states in the US, suffers from poor response time in the rural areas due to increased

expenses which were also the case when we looked at the poor EMS response time in the city of Detroit. Our research shows that the major reason for poor response time is due to lack of equipment or improper EMS personnel training and these problems arise from both the state and city wide budget cuts. Other problems were lack of standard certification procedure, systematic documentation of the nature, small operational-level PSAPs, such as poor traffic laws reinforcement, economical structure. As we looked at these problems, we came up with long term solutions rather than only solving the existing problems. Main cities in the United States such as Seattle, Washington had to formulate a plan to help endangered patients within their city. The solution may always seem simple, but it takes countless amount of time to actually achieve a solution of this caliber. Only nine major cities in the United Sates track their response times thoroughly enough to see how long it takes the emergency forces to reach a victim of cardiac arrest. If more cities persist to record data, then it will only benefit the country to reach a lower time response. It cannot be ignored that Seattle has reached the peak of having the highest survival rate for cardiac arrest cases within all the major cities in the United States and it is solely due to their creative system. The analysis for a foreign country (namely United Kingdom) shows how even the most developed countries struggle to meet time response goals. However, the recent framework developed by local and national bodies in The UK incorporates a set of 'High Impact Changes' which range from human to technological factors. A lot of regional EMS bodies have already shown signs of major improvement as indicated by the 'Best Practices' case studies. UK, a country that has traditionally relied on state-of-the-art infrastructure and superior transport means now realizes that the EMS industry needs just more than the latest ambulances and six lane roads to provide the best patient care or EMS service. The improvement philosophy initiates from the principle that ambulance service operations need to be designed not only to avoid performance failure, but also to enable continuous improvement across the whole organization.

As we looked at these problems, we focused on various technological approaches to derive solutions as these will allow us to utilize both the financial and human resources that are available to us. These technologies have been implemented in various countries outside the United States and were brought into play here in Massachusetts. Since most emergencies can't be anticipated it is best to prepare the emergency responders with the best available tools that they can have. This is where Opticom GPS system, color coding, Q-CPR comes in. These systems equip the emergency responders to respond to an emergency situation within the shortest time possible. These state-of-the art technologies also enable the emergency responders to handle critical situations with ease. These along with placing ultrasound systems in ambulances as well as implementation of Philips Periodic Clinical Data Transmission system in the ambulances will not only help improve the emergency responders it will also reduce the response time helping save valuable time and life. AACN and NG-911 are other few technologies that can have a huge impact on ameliorating response times in the United States. The proper production and management of AACN-integrated vehicles is a necessity, if this technology is to develop positive outcomes. Furthermore, NG-911 is an infrastructure upgrade. This will take a lot of time and effort and even with all this; it still won't be accessible to some of the residents who live in the lower-class society. These people cannot afford the technological devices that are required. The invention of the M-PC by Microbus has developed into a key device in Europe to reduce time response. The ambulances that have the M-PC installed have the ability of in- vehicle computer driving a dual touch screen solution which significantly benefits for the ambulance users, enabling dual progression of different functions instantaneously improves efficiencies and overall impacts the speed of response times. Combining the M-PC with the device named "OnStar" will completely reduce the time response related to automobile accidents. OnStar services provide the driver and passengers' audio interface so everyone in the car has the capability to contact OnStar representatives for

emergency services, like vehicle diagnostics and directions. This newly found idea developed by the TRACE IQP group can improve the time response. The signal from the OnStar is sent off from the antenna once the automobile undergoes drastic changes and/or the airbag security system deploys. The signal is received and processed by the M-PC within the ambulance. The ambulance will have the optimal navigation and the best direction to avoid heavy traffic allowing the ambulance to use the shortest route to the accident scene. Every major problem has a solution. However, the challenge of the project lies in the fact that most solutions we developed are to be implemented in an anticipated emergency medical scenario. This is where the Tabu Search Heuristic plays such a vital role. As a computer based algorithm it can predict close to thousands of scenarios every minutes. So, within an hour one could literally have the best possible ambulance deployment plan in place. However, the real power of Tabu lies in its ability to take hundreds of parameters. While most solutions are generated not considering key factors such as Traffic Movement, Sudden Weather Changes, Manpower Shortage etc., Tabu can be fed all these crucial inputs at the last minute. Once the algorithm completes, it then generates a completely new plan which has taken into consideration all the latest updates. As an open-source free software developed by a research team very much like ours, Tabu can be custom modeled to meet the demands for a particular city, district or even a state. Such flexibility makes Tabu a power utility never seen before by worldwide EMS. We are confident of its real-world applications and would like to see it in place very soon.

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Time Response Ambulatory Calls Evaluation (T.R.A.C.E.)

1

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MIRAD Laboratory-we create and develop engineering innovation, computation and technology to enrich our world.

Awareness & Motivation

- Time response for ambulances is a major concern

- Call volumes are increasing

- Maintain efficiency

- Tackles public service problems around the world

- Civilian ambulance service began in Cincinnati in 1865

- No official standard for response time in the US

- Canada doesn't have a jurisdiction that is recording and collecting time response data
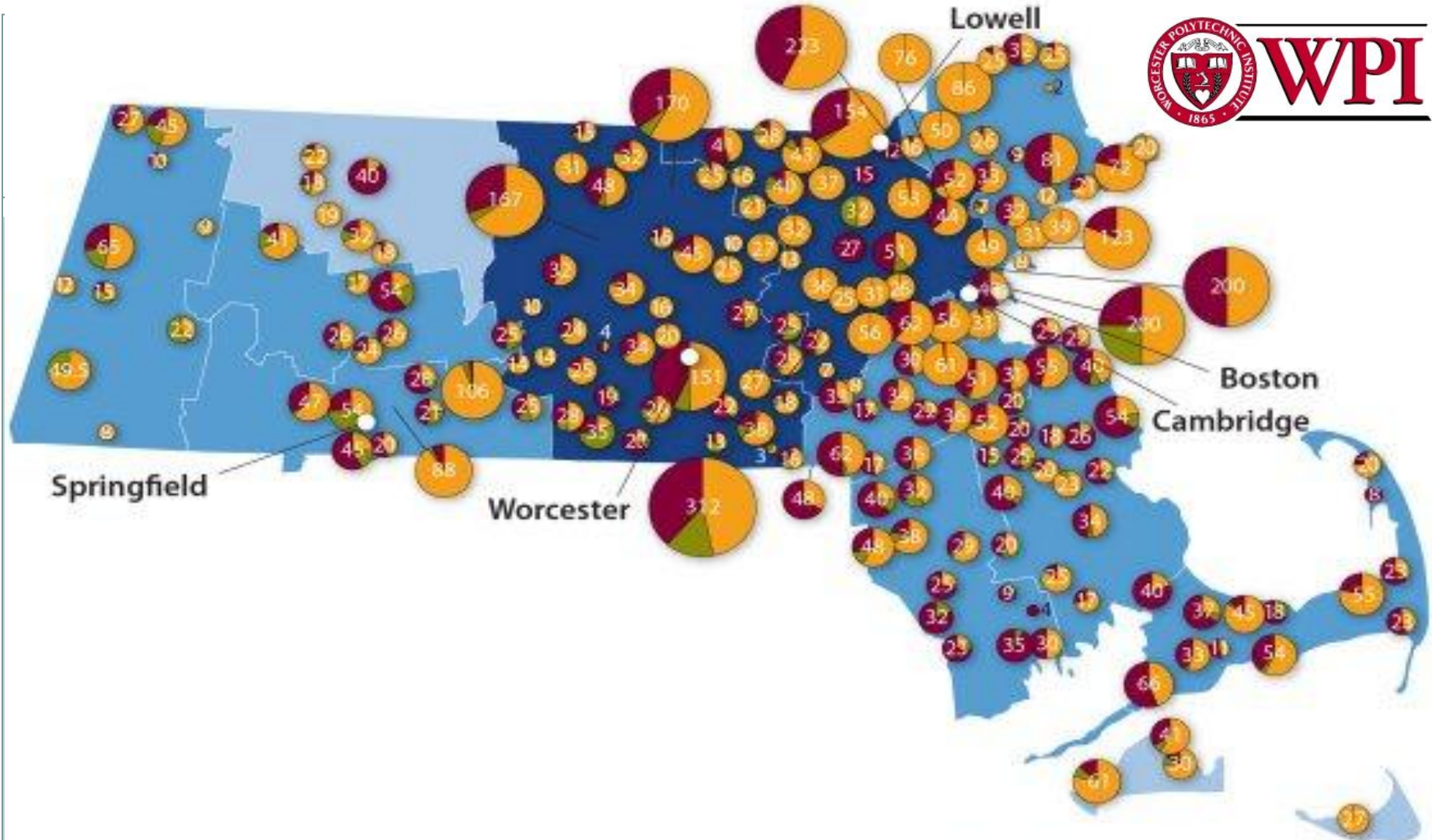
EMS Agency Personnel Types

- 🟧 EMT-Basic
- 🟩 EMT-Intermediate
- 🟥 EMT-Paramedic

The size of the pie chart is proportional to the total number of personnel, which is reflected by the number in the center of the chart.

County Total Population, 2006

- 10,820–71,693
- 71,694–731,179
- 731,180–1,463,654

County total population categories represent the lowest, middle three, and highest quintiles, respectively.

Note: EMS agency is represented at the centroid of the ZIP code in which it is located. In ZIP codes where multiple agencies responded to the survey, agencies are slightly offset from the centroid. All EMS agencies in the state are not represented on this map. Only EMS agencies that responded to the survey and answered the questions relevant to each map are included here.

- ORCON - Operational Research Consultancy

- Advanced Medical Priority Dispatch System (AMPDS)

- Ameliorate time response for ambulances

Project Formulation & Objectives

- Evaluate ambulance response times in the US

- Compare and analyze data from US with data from other countries around the world.

- Investigate into the differences of time responses in different areas and the reason for the time taken

- Design a database that will store all the response time for ambulances, which is accessible to the public

- Different types of response time measurements

- Create a standard for time response measurement for every country

Project Formulation & Objectives
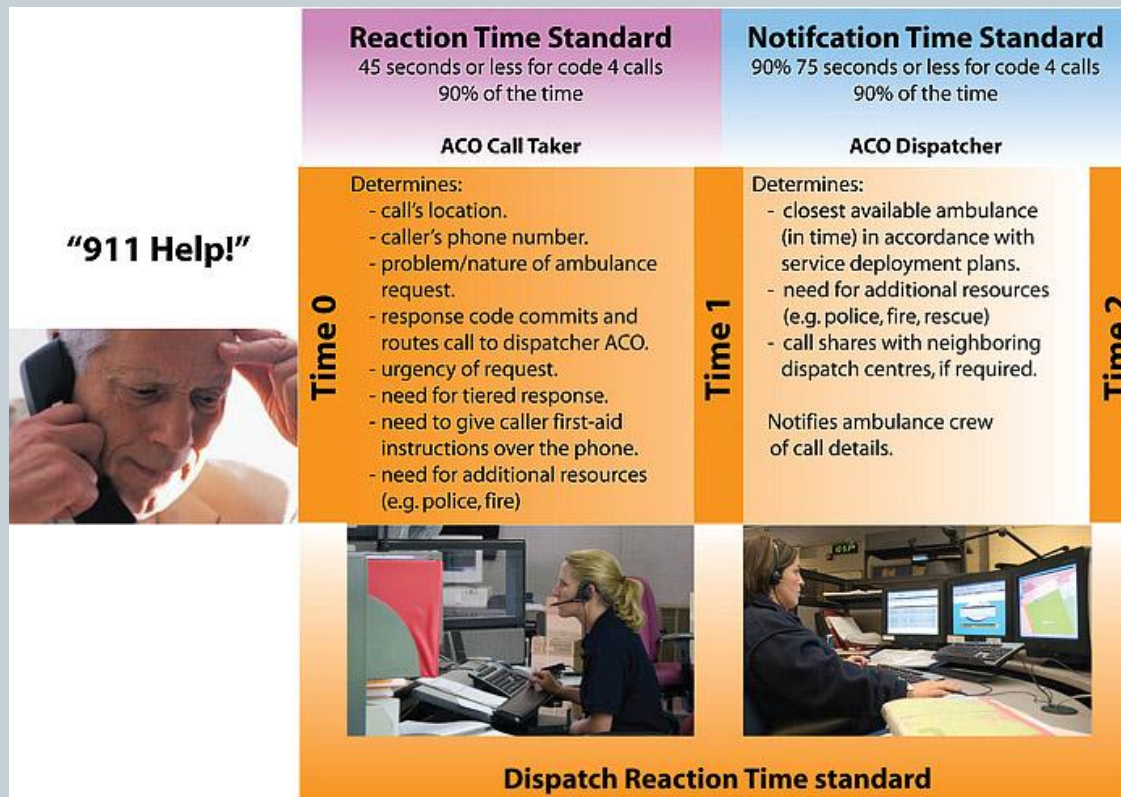
- In Ireland, having difficulty reaching <12 minutes: urban areas and <20 minutes: rural areas.

- In South Africa, 40 minutes as a response time to rural areas is considered normal.

- In UK, <8 min for urban areas and <19 min for rural areas

- As seen, rural areas are largely affected in almost every country. By almost twice the time

- How to decrease it significantly in the rural areas?

Project Formulation & Objectives

- Different types of response time measurements

- Create a standard for time response measurement for every country

Reaction Time Standard
45 seconds or less for code 4 calls 90% of the time

ACO Call Taker

Notifcation Time Standard
90% 75 seconds or less for code 4 calls 90% of the time

ACO Dispatcher

"911 Help!"

Time 0

Determines:
- call's location.
- caller's phone number.
- problem/nature of ambulance request.
- response code commits and routes call to dispatcher ACO.
- urgency of request.
- need for tiered response.
- need to give caller first-aid instructions over the phone.
- need for additional resources (e.g. police, fire)

Time 1

Determines:
- closest available ambulance (in time) in accordance with service deployment plans.
- need for additional resources (e.g. police, fire, rescue)
- call shares with neighboring dispatch centres, if required.

Notifies ambulance crew of call details.

Time 2

Dispatch Reaction Time standard

What is fascinating about the project?

- There has been small scale analysis for local time response statistics. For the first time, a global analysis is being done.

- Is Response Time really the best indicator of EMS Ambulance Efficiency?

- If yes, how can it be improved?

- If no, which parameter prevails over Time Response in relaying critical information?

- Co-relating variables for creating aforementioned parameter.

What is fascinating about the project?

- The many external factors that affect Response Times.

- External factors vary from place to place and from time to time.

- Extremely harsh climates and their impact.

- Massive variations in infrastructure across the globe.

What is fascinating about the project?

- Creating a database of statistics for time Response for various cities and states across USA.

- Creating a database of statistics for Time Response for various countries in the world and comparing them to find/study a pattern.

- Finding a viable solution and proposing it to a target area.

- Studying results of solution implementation and execution.

- What counts as EMS ambulance and what does not?

http://www.armyrecognition.com Rheinmetall AG ©

What is challenging about the project?

- Collection of such huge data and verification would require enormous team effort and a lot of resources.

- Making the database open to the public would mean a lot of feedbacks and criticism and coping with them is definitely a challenge.

- Keeping in mind what can be compromised and what can't.

- Conducting large scale interview sessions with some of America's largest EMS Paramedic and Ambulance Services.

What is challenging about the project?

- Learning the time response data in MA and various EMS epicenters therein.

- Knowing and understanding technical aspects of an ambulance is critical to propose a viable solution.

- Finding a testing environment where solutions can be effectively tested and where calculated results imitate real world scenarios.

- Lack of ownership – Due to the EMS industry being decentralized a uniformity cant be found and solutions have to customized, flexible and tailor-made.
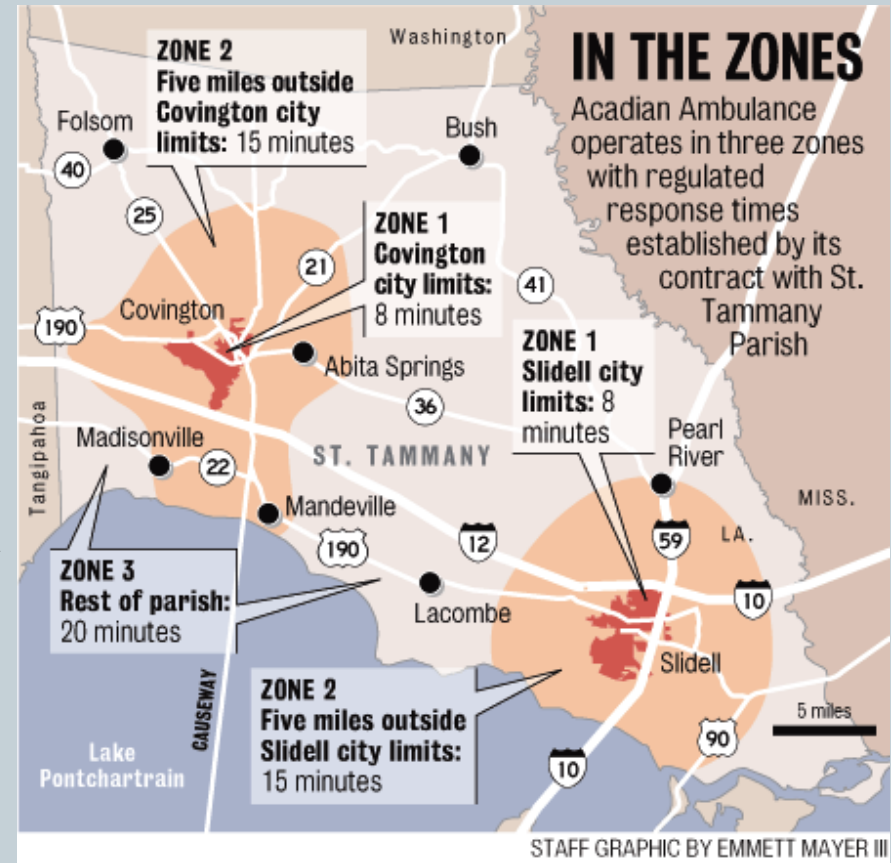
What is challenging about the project?

- Meeting deadlines – Since a lot of our data analysis is done with overseas communication, deadlines are always a worry!

- Risk Management – It is crucial to understand the huge risk that EMS officials take upon themselves, so mathematics can only go till a certain distance to enhance response times.

- Ambiguous Contingency Plans - It's important for project managers to know exactly what direction to take in pre-defined "what-if" scenarios.

Where does our Project Fit into the Greater Scheme of Things?

14

- It's a public service commodity

- Millions of lives can be saved, especially people in rural areas, if a better plan is installed.

- Major advancements have been made in medicine, but what's the use if the time response is not equally matched.

ZONE 2
Five miles outside Covington city limits: 15 minutes

ZONE 1
Covington city limits: 8 minutes

ZONE 1
Slidell city limits: 8 minutes

ZONE 3
Rest of parish: 20 minutes

ZONE 2
Five miles outside Slidell city limits: 15 minutes

IN THE ZONES
Acadian Ambulance operates in three zones with regulated response times established by its contract with St. Tammany Parish

STAFF GRAPHIC BY EMMETT MAYER III

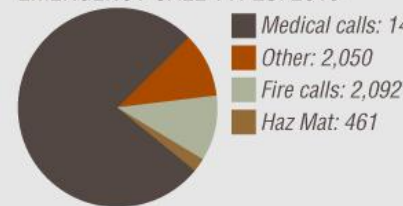# Where does our Project Fit into the Greater Scheme of Things?

15

- Prioritizing assistance according to the severity of the injury
- Educating the general public on the advancements in this field
- Setting up a database for the public to refer to when searching for areas with better time responses

AMBULANCE RESPONSE TIMES

LINCOLN FIRE AND RESCUE'S GOAL IS TO ARRIVE ON THE SCENE WITHIN 8 MINUTES, 90 PERCENT OF THE TIME

911

1. Person calls 911 for a medical emergency or fire

2. After the call, firefighters or EMTs have 60 to 80 seconds to prepare and leave.

3. Drive time goal: 6 to 7 minutes

EMERGENCY CALL TYPES: 2010

- Medical calls: 14,999
- Other: 2,050
- Fire calls: 2,092
- Haz Mat: 461

LFR RESPONSES, 2010

- 88.32% of the time, LFR responds in less than 6 minutes -- that's up from the 88.05% in the last three years.
- 95.44% of the time, LFR responds in between 6 and 7 minutes -- that's up from the 94.91% in the last three years.

Source: LFR 2010 annual report

Jordan Pascale and Katie Nieland / JournalStar.com

Where does our Project Fit into the Greater Scheme of Things?

16

CHAIN OF SURVIVAL

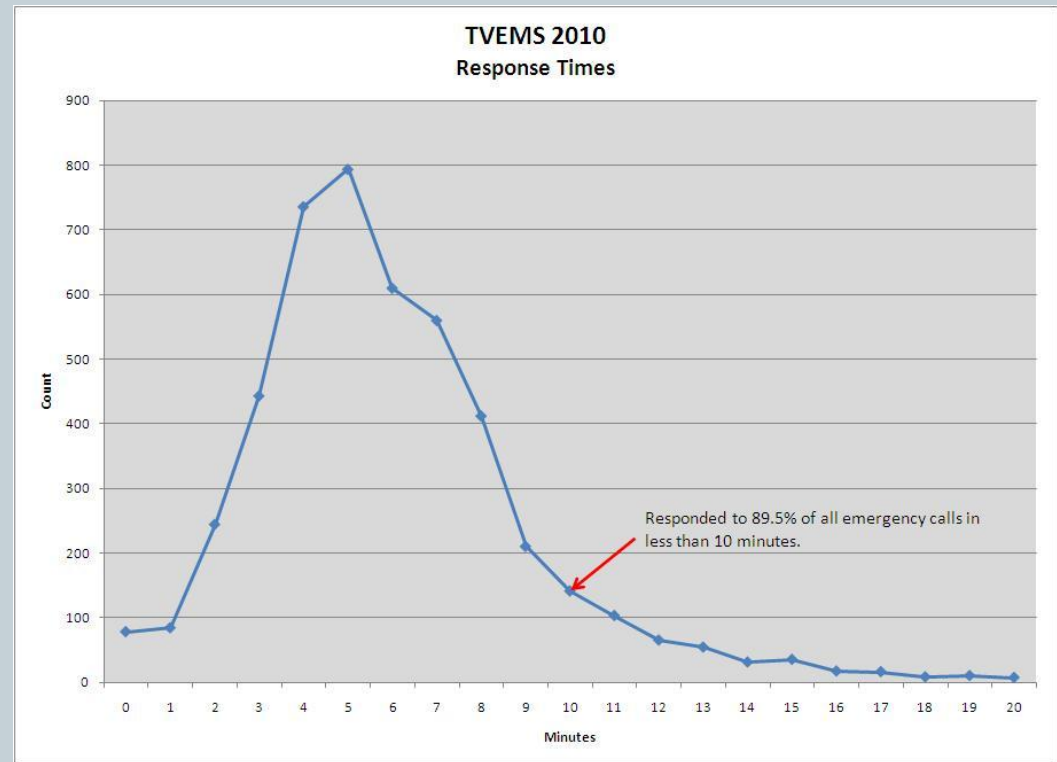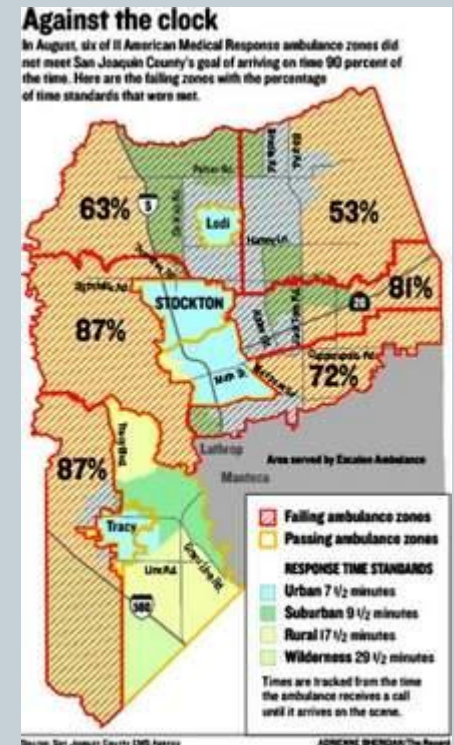| Early Access	Early CPR	Early Defibrillation	Early Advanced Care
1	**2**	**3**	**4**

- Analyzing the data and figuring where the major problem lies

- General trends seen in the time response data. How can these trends be improved?

- Ameliorating time response in rural areas will be a major source for our solution

Thompson Valley, Loveland, CO

- Looking into the factors that ambulances have to overcome during their path to the patient.

- Analyzing, in detail, the pathway from when a patient dials 911 to the time the ambulance takes off.

Against the clock

In August, six of 11 American Medical Response ambulance zones did not meet San Joaquin County's goal of arriving on time 90 percent of the time. Here are the failing zones with the percentage of time standards that were met.

63% 53% 81% 87% 72% 87%

Area served by Escalon Ambulance

Failing ambulance zones
Passing ambulance zones

RESPONSE TIME STANDARDS
Urban 7 1/2 minutes
Suburban 9 1/2 minutes
Rural 17 1/2 minutes
Wilderness 29 1/2 minutes

Times are tracked from the time the ambulance receives a call until it arrives on the scene.

FACTORS DELAYING RESPONSE TIME

•We will analyze the structure and develop a solution to better the system.

The Process of Locating and Interpreting the Solution

- Once possible solutions are listed, each could be implemented and experimented

- Simulations could be run to test the solutions

- Implementing these solutions on the large scale basis will pose further challenges

- A few tests in real life situations will give us a better understanding of the strength of the solutions produced

The Process of Locating and Interpreting the Solution

• We will take into consideration many factors and try to implement ideas to improve time response in the modern day.

• The recorded data for time response in different regions are evaluated and are used to understand the problem.

• Understanding how and why these problems occur will assist our group to find a solution or even minimize the on going problems.

y At the EMS garage in UMass, the EMTs conveyed the problems they encounter on a day-to-day routine.

y Our goal is to actually witness EMS in action and examine the details to evaluate their process.

y If we are capable to visualize the process it can ease our attempts to create a simulation of the actual scenario.

Factors to consider toward a Solution

➤ Helps us identify and realize the complexities in Emergency Management and Disaster Response Information System (EMRDIS) that exist in different parts of the world at it's core.

➤ Links the traditional complexities of emergency systems to modern technological, cultural complexities as cities become more cosmopolitan.

➤ Based on our research the EMRDIS complexities can be identified as follows—

1. Human
2. Situation Characteristics
3. Technology Infrastructure
4. Interaction
5. Cultural
6. Decision Making

Possible solutions and why are they important to the project

➢ Looking at Burnaby Police and Fire Departments Emergency Response system Research which invented the Opticom system we can work toward a better emergency response system.

➢ Opticom enhances traffic system by allowing emergency vehicles activate traffic signals from greater distances. This offers a more accurate signal preemption and remote monitoring which is vital for crowded cities.

➢ Opticom only expedites traffic system which solves the technological part of the EMRDIS complexities.

Fairfax County, Virginia

Possible solutions and why are they important to the project

Possible solutions based on situation and characteristic complexities and How to improve Human and interaction complexities.

➢ *Designing EMS interfaces with supplementary cues will result in lower perceived cognitive effort.*

➢ *Designing ERS interfaces with supplementary information cues (color and sorting) will improve dispatcher information selection speed.*

➢ *In high time pressure situations, the use of two supplementary cues will be more effective at improving dispatcher information selection speed than the use of only one supplementary cue.*
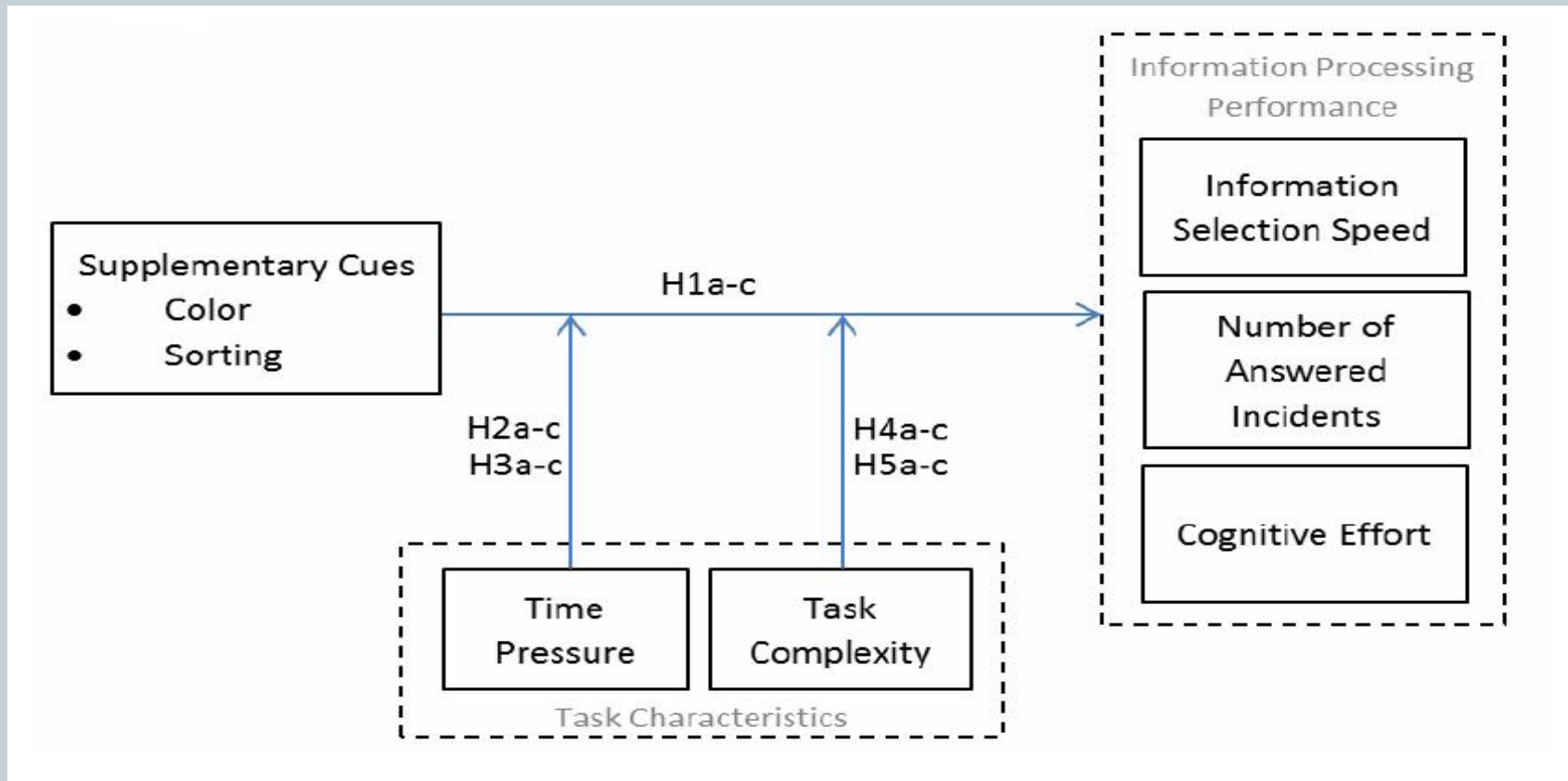
*Color is used as information cue and sorting as location cue

Possible Solution in reducing human and interaction complexities

Possible solutions and why are they important to the project?

28

Why are the derived solutions important to the project?

- How do we implement the Opticom system in third world countries where traffic system is barely obeyed?
- How to come up with EMS system that doesn't hurt any sort of cultural or religious sentiment?
- How to train personnel and update training that keeps up with present technological and technical advancement?
- Come up with a solution that can be applied at any part of the world?

So, what can YOU do?

y Questions for the greater society-

y What can you do to better enrich our way of life and world?

y How can a single person help save the life of another person hundreds of miles from him?

y To what extent does the society affect Ambulatory time response statistics?

y Why should YOU be interested?

y SIMPLE ANSWER – From 1997`-2003, approximately one in seven (14%) of the American population used an Ambulance. Someday YOU could be that 'one' and how the society responds to the EMS Time Response System could be vital to your life.

So, what can YOU do?

y DO NOT CALL 911 for minor injuries/cuts - Your Insurance covers your ambulance fees, BUT does it guarantee the safety of a gravely injured person who actually needs it?

y DO NOT HESITATE to call 911 if you see any ambulance-needy person. The paperwork involved is minimal and it will take 20 minutes of your life to save another.

What else can YOU do?

y LEARN Basic Cardio Pulmonary Resuscitation (CPR). Most EMS personnel agree that it is the most effective way to stabilize body vitals immediately after an accident/stroke.

y EVACUATE the immediate vicinity of the injured.

• MAKE sure the person is in an easily transportable position.

• DO NOT leave him alone till EMS Ambulance shows up.

CALL
CALL 911

BLOW
TILT HEAD, LIFT CHIN, CHECK BREATHING
GIVE TWO BREATHS

PUMP
POSITION HANDS IN THE CENTER OF THE CHEST
FIRMLY PUSH DOWN TWO INCHES ON THE CHEST 30 TIMES

CONTINUE WITH TWO BREATHS AND 30 PUMPS UNTIL HELP ARRIVES

SOLUTIONS

Improvement in EMT Reporting

y **Both Centralized & Decentralized –**

- - Integration with existing PBX or CENTREX telephone system for additional, proprietary or specialized controllers.

- - Accelerated emergency response time—a more efficient PSAP (public safety answering point) that provides more accurate and faster emergency dispatching to the proper agencies translates to better service to members of the community.

- - Ability to operate through Windows on a PC—by using such a familiar interface, call takers makes such an important task incredibly simple.

Case Study – The City of Newark, NJ

y **The City of Newark, NJ is averagely sized at 26 square miles, however it has a population of 277,140. (11,000 people/sq mi).**

- - Amcom Software's XTEND pc/psap™ is a PC/LAN based Intelligent Workstation PSAP (Public Safety Answering Point) application that replaces traditional call taking solutions with the flexibility of a software based system, combined with the reliability of a PBX (Private Branch Exchange).

- - When a 911 call is received the ANI or unique identifier is provided with the call. pc/psap uses this information to fetch the location information (ALI) from the Verizon ALI database.

The call is answered on the pc/psap workstation

with the victim caller's information. This

information is immediately displayed on

the PC-workstation of the Newark call taker.

Surrey Air Ambulance medics saved woman trampled by horses

Surrey Air Ambulance medics saved Lottie Taylor when she was trampled by horses

SURREY AIR AMBULANCE WAS SCRAMBLED AND THE CREW GAVE EMERGENCY TREATMENT AT THE SCENE BEFORE FLYING THE 24-YEAR-OLD TO A TRAUMA CENTER IN LONDON.

MIRAD Laboratory-we create and develop engineering innovation, computation and technology to enrich our world.

OPTICOM SYSTEM

❑ OpticomGPS system is installed in the traffic system at an intersection it allows Police and fire department vehicles to activate specific traffic signals from a great distance

Dispatcher Assistance

❑ Color System for dispatcher-time will be reduced as the need for dispatcher to find and assign an EMS system will be eliminated.

❑ Various colors will be assigned to various injuries.

❑ Eliminate the need to go through various codes and helps make better decisions.

❑ Implementation of 311-call system.

Q-CPR, Ultrasound in Ambulance

- ❑ Q-CPR is a more proven modern CPR technology compared to traditional CPR devices.

- ❑ Ultrasound can help provide a quick detection of cardiac arrest, trouble with pregnancy, trauma, and tamponade.

Q–CPR Meter   Compress deeper   Release pressure between compressions   Compress slower

❑The HeartStart Telemedicine system by Philips can also be used to connect the EMTs to doctors.

❑Provides critical data to doctors ahead of patient arrival at the hospitals in case of critical situations.

M-PC and OnStar Combined

- y Improving ambulance response times through accurate and timely information
- y Microbus in-vehicle computers are used extensively within the Ambulance market across Europe and their comprehensive installations have improved operational efficiency
- y The computer's multi-bearer flexibility allows users to send and receive data over any radio network from 3G/GPRS to TETRA.

M-PC and OnStar Combined

y OnStar Corporation is a subsidiary of General Motors that provides subscription-based communications, in-vehicle security, hands free calling, turn-by-turn navigation, and remote diagnostics systems throughout the United States.

M-PC and OnStar Combined

y To better the system in the most technological way is to combine the two systems.

y M-PC is essentially a computer system within an ambulance that is capable of receiving messages without the help of the dispatcher.

y OnStar services take up time to send the message to the OnStar call center and then forward it to the dispatch.

y The device installed into new model vehicles can directly contact the ambulance instead of the dispatcher.

Advanced Automatic Collision Notification (AACN)

- Implemented in motorized vehicles

- Eliminates the need for the person to make a call

- Sensors provide information such as speed, change in velocity, vehicle occupants, GPS location, etc.

- The module contains useful data about the vehicle and owner
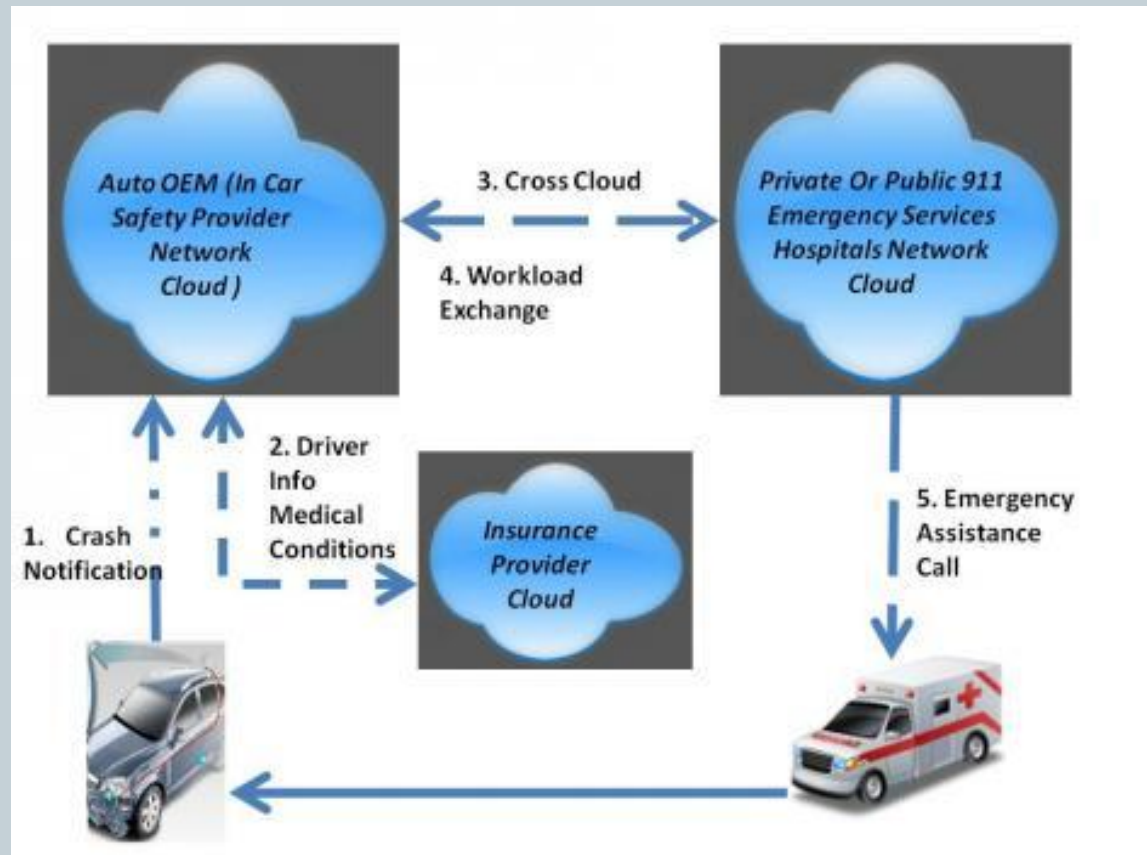
Next Generation 9-1-1

- Aims at improving infrastructure

- Relies on an Emergency Services IP Network (ESInet) to deliver voice, video, text and necessary information to the PSAP
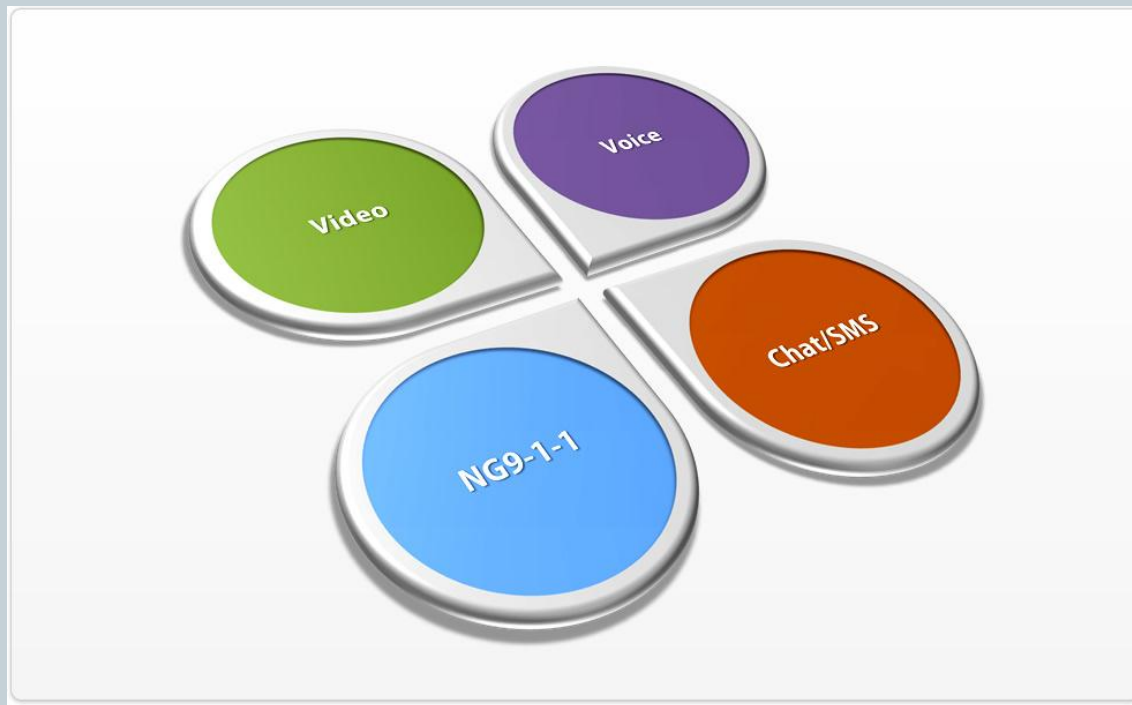
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y Dave Whiting, Director of Operations

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Q&A !!